PLANT PATHOLOGY

A RECORD OF CURRENT WORK ON PLANT DISEASES AND PESTS

Published quarterly for the
Ministry of Agriculture, Fisheries and Food
Plant Pathology Laboratory
Harpenden, Herts

VOLUME 6, No. 2
June 1957

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EXPERIMENTS ON ORCHARD SPRAYING FOR THE CONTROL OF *GLOEOSPORIUM* STORAGE ROTS OF APPLES

by R. W. MARSH

Research Station, Long Ashton, Bristol

H. B. S. MONTGOMERY

Research Station, East Malling, Kent

AND K. L. EDNEY

Ditton Laboratory, Larkfield, Kent

The wastage of Cox's Orange Pippin apples held in storage, by rots caused by species of *Gloeosporium*, has become a serious problem in recent years. Many of the factors concerned in the incidence of the disease and in the susceptibility of apples have not yet been worked out, but the urgency of the problem made it desirable to find some means of direct chemical control. This interim report records the results of replicated trials of sprays applied to fruiting apple trees at various dates during August and September. Fruits from the treated trees, together with controls, were subsequently harvested at the normal time and samples were stored at 37°F. The fruit storage, with the recording of rots, was done throughout at the Ditton Laboratory ; the spraying trials on Cox's Orange Pippin were carried out under the supervision of East Malling Research Station and those on Allington Pippin at Long Ashton Research Station.

TRIALS ON ALLINGTON PIPPIN

The trials at Long Ashton were made on 48 trees (4 rows of 12) of Allington Pippin set out on a 30 foot square plant. The plot, of which these trees formed part, was planted in 1920 and grassed down in 1955. From 1953 onwards, the whole plot received annually two pre-blossom lime sulphur sprays at 1 per cent and two post-blossom sprays at ¾ per cent, the latest lime sulphur spray being three weeks after petal-fall. For the late summer sprays (*see* Table 1) the 48 trees were divided into twelve 2 × 2 blocks, with each treatment applied to one or more trees in each block. All applications were made as high volume sprays. At harvest, all the fruits were picked and the requisite half-bushel samples for each tree were taken from the corners of the orchard boxes. These samples were taken to Ditton on the day, or day after, they were picked, and immediately stored at 37°F. The treatments and results in three successive seasons, are summarized in Table 1.

Table 1 shows that in the first season's trial captan and ziram gave better results than glyodin : the 1954–55 trial, in which only captan was used, indicated that an August spray plus a September spray was more advantageous than an August or September spray. The third trial, made in a year of light infection, again suggests that the August and September spray increased the protection against *Gloeosporium* rots in the later stages of storage. Even the double-spray applications were only partially successful, but the results support the view that spraying treatments may increase the level of control that is attainable by orchard management practices.

TABLE 1

TRIALS ON ALLINGTON PIPPIN AT LONG ASHTON

Season	Spraying Dates	Spray	Mean Percentage of Fruits Showing Rots			
			Dec. 1	*Dec. 8*	*Dec. 29*	*Jan. 1*
1953–54	Aug. 17 and Sept. 9	Captan 0·1%	4	6	17	30
		Ziram 0·2%	10	12	14	27
		Glyodin 0·1%	17	21	31	58
		Control	24	34	48	66
			Dec. 6	*Dec. 20*	*Jan. 4*	
1954–55	Aug. 16	Captan 0·1%	11	21	27	
	Sept. 22	Captan 0·1%	9	15	21	
	Aug. 16 and Sept. 22	Captan 0·1%	7	12	18	
		Control	19	33	41	
			Dec. 17	*Jan. 7*	*Feb. 2*	
1955–56	Aug. 20 and Sept. 17	Captan 0·1%	1	1·5	1	
	Sept. 17	Captan 0·1%	1	2·5	4	
		Control	3	5	7	

TRIALS ON COX'S ORANGE PIPPIN

Following the partial success of the use of captan and ziram in the 1953 trial on Allington Pippin at Long Ashton, a replicated trial on Cox's Orange Pippin was carried out at Kirdford, Sussex, in 1954. In 1954 also, a series of experiments was undertaken at the request of the Agricultural Research Council, in which simple replicated trials with captan were carried out on five farms in Kent and two in Suffolk ; one farm in Kent provided two sites.

The trial at Kirdford was carried out on 24 trees, the three treatments—0·1 per cent captan, 0·2 per cent ziram, and control—each being replicated eight times. One tree sprayed with captan did not bear a large enough crop for the necessary samples and was excluded. Sprays were applied on August 5 and August 26, 1954. The fruit was picked on September 28 in dry weather and was sampled and placed in store by September 30. The results are given in Table 2.

TABLE 2

TRIALS ON COX'S ORANGE PIPPIN AT KIRDFORD, SUSSEX, 1954

	Mean Percentage of Fruits Showing Rots			
	Nov. 10	*Nov. 24*	*Dec. 8*	*Dec. 22*
Captan	9·5	21·0	30·5	39
Ziram	15·0	19·5	31·5	46
Control	20·5	33·5	39	46·5

The fruit was badly cracked and this factor undoubtedly resulted in a higher degree of rotting than is desirable in a trial of this type. In commercial practice, badly cracked fruit would be considered a bad storage risk and either marketed immediately or held in store for a short period only. However, the reduction in rotting noted at the first inspection shows that spraying with captan gave some measure of control.

In the trials in Kent and Suffolk, the layout at each site consisted of four plots, two unsprayed and two sprayed, each of 5 × 5 mature, bearing trees of Cox's Orange Pippin. The plots were either in lines of four, with the sprayed and unsprayed alternately, or in the form of a 2 × 2 square, with the two sprayed plots diagonally opposite each other. On two sites, slight modifications to the arrangement were introduced.

The trees had already received normal routine scab sprays varying according to each grower's choice. The experimental applications of 0·1 per cent captan were made by the grower as high volume sprays, the first being applied between August 4 and 9 and the second between August 19 and 27. Local conditions affected the timing of these sprays and also the dates of harvesting the fruit. Most of the sites were picked during the first week of October, but two sites in Kent were picked on October 12 and another, also in Kent, on October 22.

Two bushels of fruit for storage were taken from the picked crop of four trees in each plot, sampling from the corners of every box. This sample was subdivided at Ditton Laboratory into six sub-samples of 25 apples and put in cold storage at 37°F. Examinations were made at monthly intervals from November to March, using separate samples on each occasion, and the numbers of fruits attacked by *Gloeosporium* spp. were recorded. At the first examination, on November 10, losses were negligible. The results of the other examinations showed considerable variation from site to site, but an effect of spray treatment was revealed at all sites ($P<0·001$), except at the one picked latest, on October 22. As this very late picking was probably responsible for the lack of any effect, the figures for this site have been omitted from the analysis and the summarized figures in Table 3.

TABLE 3

TRIALS ON COX'S ORANGE PIPPIN IN KENT AND SUFFOLK, 1954–55

	Mean Percentage of Fruits Showing Rots					
	Dec. 8	*Jan. 11*	*Feb. 9*	*March 10*	*March 31*	Overall Mean*
Sprayed ..	0·3	3·4	5·7	20·8	39·2	9·7
Control ..	4·6	4·9	16·8	47·4	57·7	21·4

* Derived from figures transformed to angles of equal information.

CONCLUSION

The results of the trials indicate that some reduction of apple storage rots due to *Gloeosporium* can be achieved by late summer spraying in the orchard with a suitable fungicide.

We thank the growers concerned for their kindness in providing facilities for this work. The contribution of one of us (K.L.E.) was made as part of the programme of the Food Investigation Section of the Department of Scientific and Industrial Research.

CONTROL OF CLUB ROOT OF BRASSICAE

by W. R. ROSSER

National Agricultural Advisory Service, Wolverhampton

A pilot trial on the control of Club Root, *Plasmodiophora brassicae* Wor., by the use of griseofulvin, cadmium chloride, mercuric chloride, and pentachloronitrobenzene was carried out in 1956 on heavily-infected land at Wolverhampton.

Griseofulvin. Brian *et al.* (1951) and others have shown that this compound possesses activity as a systemic fungicide. In the present trial, it was applied twice to the seedbed as a 30 per cent dust, at the rate of 1 ounce per 100 feet of drill. At transplanting, the roots of the plants were dipped in a slurry obtained by mixing 1 lb of 50 per cent wettable powder in 5 gallons of water.

Cadmium chloride. Fungicides containing compounds of cadmium are used extensively in the U.S.A. for disease control on turf. Drew Smith (1955) has successfully used similar compounds experimentally for the same purpose in this country. McCallan and Wilcoxon (1934), Seifriz and Uraguchi (1941), and Frear (1948) have commented on the fungicidal properties of the element. In this trial, a 1 in 2000 solution of cadmium chloride (99 per cent $CdCl_2 \cdot 2\frac{1}{2}H_2O$) was applied at the rate of $\frac{1}{2}$ pint to each dibble hole at transplanting. The mercuric chloride and pentachloronitrobenzene were also applied in this manner.

Mercuric chloride. This is a recognized standard treatment for the control of the disease, and it was used as a 1 in 2000 solution (Preston, 1928).

Pentachloronitrobenzene. Both Smieton (1939) and Preston (1941) reported good control of the disease using chlorinated nitrobenzenes. Recently, in the U.S.A., Gallegly and Bishop (1955) used a 75 per cent formulation and claimed a good control of the disease at 80 lb per acre as a soil treatment, or at 2, 4 or 8 lb per 100 gallons as a transplant water treatment. At Wolverhampton, the compound was a 75 per cent wettable powder formulation used as an aqueous suspension containing 0·75 per cent of the active ingredient.

CONDITIONS OF TRIAL

On April 4, seed of the cabbage variety Ellam's Early was sown in drills 12 inches apart on a seedbed where previous cropping had shown no evidence of Club Root. After 13 days, seedling emergence was 90 per cent and the griseofulvin dust was applied to a portion of the seedbed. The soil was extremely dry, and four days after applying the dust the treated seedlings showed a scorching of the foliage and later appeared to have been slightly checked in their growth. Watering of the seedbed was necessary because of the drought, and on May 8 the plot was dusted with a proprietary DDT flea beetle dust. The area of seedbed previously treated with griseofulvin was, thirty-four days later, again treated in the same manner without apparent adverse effect on the plants.

Transplanting was carried out on June 14 at the end of a prolonged period of drought. The experimental area was coarse sandy loam at a pH of 6·1 and was known from previous experience to be fairly uniformly and heavily infected. It had received a dressing of farmyard manure equivalent to 2 tons per acre, but no artificial fertilizers were used.

A randomized block layout was employed with 8 replications of each treatment. The untreated control plots were replicated 16 times, there being 2 such plots per block, and the untreated plants were inserted directly into the appropriate dibble holes at transplanting. Each plot contained 17 plants—2 outer rows of six plants each, and a central row of five plants which alternated with those in the outer rows. There were 136 plants per treatment (272 untreated). The distance between plants was 18 inches, between rows 24 inches, and between plots 36 inches.

EFFECTS OF THE TREATMENTS

A definite check to growth was evident 13 days after transplanting in all treatments except griseofulvin and in the control. By August 8, this check could no longer be detected, and on this date a count of missing and wilted plants was made. These counts are entered in brackets in Table 2.

TABLE 1

EFFECT OF TREATMENTS ON THE CROP

(Means per plot of 17 plants)

Treatment	No. of Healthy Plants	No. of Marketable Heads	Weight of Tops *lb*	Weight of Roots *lb*
Griseofulvin	4·50	12·00	28·00	3·09
Cadmium chloride	5·13	10·25	27·13	2·41
Mercuric chloride	9·63	15·00	39·88	2·91
Pentachloronitrobenzene	8·50	8·63	21·13	1·52
Control	3·56	8·04	22·13	3·32
Standard error per plot	2·77	2·50	6·67	0·72
Significant difference:				
between any 2 treatment means.. ..	4·04	3·15	6·71	0·98
between any treatment mean and control	2·41	2·18	5·81	0·63

(P = 0·05)

Ninety-one days after transplanting, that is, on September 13, it appeared that the majority of the plants capable of bearing marketable heads were, in fact, doing so, and lifting was carried out on that date in dry weather conditions. The observations on the number of marketable heads, the weight of produce, and the weight of the roots after careful washing are given in Table 1. An analysis of the Club Root attack is given in Table 2.

TABLE 2

ANALYSIS OF CLUB ROOT ATTACK ON THE PLANTS

(No. of plants in 136)

Treatment	No Disease	Attack on Lateral Roots		Attack on Tap Roots		Indeterminate (Wilting)	Missing Plants
		slight	*severe*	*slight*	*severe*		
Griseofulvin ..	36	10	6	1	68	12 (6)*	3 (1)
Cadmium chloride	41	14	4	2	48	8 (7)	19 (16)
Mercuric chloride ..	77	51	5	0	0	0 (0)	3 (1)
Pentachloronitro-benzene	68	24	7	0	13	7 (6)	17 (15)
Untreated	29	7	6	2	68	8 (10)	18 (17)

* Counts in brackets are for August 8, others September 13.

The summer of 1956 was extremely wet, the August rainfall of 4·84 inches being twice the average for that month. A decrease in fungicidal effectiveness

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through dilution or leaching in the soil might, therefore, have been expected, but, in spite of this, a very good disease control was obtained by the use of both pentachloronitrobenzene and mercuric chloride. The control of infection obtained with mercuric chloride was correlated with a yield of green matter significantly higher at $P = 0{\cdot}01$ than that obtained by any other treatment.

The yield obtained with the use of pentachloronitrobenzene was not significantly different from that from the untreated plants. The weight of the root systems of plants treated with this compound was however significantly low, indicating the possibility of a phytotoxic effect in the rhizosphere. At no time during the trial did the plants treated with PCNB show any overground symptoms, and their recovery from the transplanting check was as rapid as that of plants in any other treatment where a check occurred. Smieton (1939) considered that the phytotoxicity of the chlorinated nitrobenzenes which she used varied with the nature of the filler, and the anomalous performance of PCNB in this trial requires further investigation.

Griseofulvin and cadmium chloride both gave a poor control of the disease. Although the plants treated with the former compound gave a significant yield of marketable heads, the weight of green matter resulting from the use of either compound was significantly lower than that obtained by the use of mercuric chloride.

I wish to thank Mrs. M. Jones and Mr. W. E. Perry for their help in this trial.

REFERENCES

BRIAN, P. W., WRIGHT, J. M., STUBBS, J. and WAY, A. M. (1951). Uptake of Antibio Metabolites of Soil Micro-organisms by Plants. *Nature*, **167**, 347–8.

DREW SMITH, J. (1955). Fungi and Turf Diseases. *J. Sports Turf Res. Inst.*, **9**, 47–59.

FREAR, D. E. H. (1948). *A Catalogue of Insecticides and Fungicides*. II. Chronica Botanica, U.S.A.

GALLEGLY, M. E. and BISHOP, C. F. (1955). Pentachloronitrobenzene for Control of Clubroot of Crucifers. *Plant Dis. Reptr*, **39**, 914–7.

MCCALLAN, S. E. A. and WILCOXON, F. (1934). Fungicidal Action and the Periodic System of the Elements. *Contr. Boyce Thompson Inst.*, **6**, 479–500.

PRESTON, N. C. (1928). Experiments on the Control of Finger and Toe in Cabbages by the Use of Mercuric Chloride and Other Substances. *Welsh J. Agric.*, **4**, 280–95.

PRESTON, N. C. (1941). Experiments on the Control of Club Root of Brassicae in Gardens and Allotments. *Ann. appl. Biol.*, **28**, 351–9.

SEIFFIZ, W. and URAGUCHI, M. (1941). The Toxic Effects of Heavy Metals on Protoplasm. *Amer. J. Bot.*, **28**, 191–7.

SMIETON, M. J. (1939). On the Use of Chlorinated Nitrobenzenes for the Control of Club Root Disease of Brassicae. *J. Pomol.*, **17**, 195–217.

EFFECT OF BLACK RUST ON YIELD OF WHEAT IN SOUTHERN ENGLAND IN 1955

C. C. V. BATTS* AND C. S. ELLIOTT

National Institute of Agricultural Botany, Cambridge

Black Rust, *Puccinia graminis* Pers., was severe on wheat crops in some parts of England in 1955. A general account of the attack has been published in this JOURNAL (*Plant Pathology*, 1956, **5**, 38). Some indications of the effect of the rust on grain yields were given, but more detailed information is presented here.

In addition to the trials and other plots grown at the Regional Trials Centres of the National Institute of Agricultural Botany, a large number of wheat trials are carried out each year on farms in all parts of the country in conjunction with the National Agricultural Advisory Service. The N.A.A.S./N.I.A.B. spring wheat trials in Hampshire, East Sussex, Wiltshire, Devon and Cornwall were severely affected by the disease and yields were considerably reduced.

AVERAGE YIELDS OF SIX SPRING WHEAT VARIETIES IN N.A.A.S./N.I.A.B. TRIALS, 1955

Variety	(*a*) No Black Rust Present		(*b*) Black Rust Severe		Percentage Decrease in Yield Between (*a*) and (*b*)
	No. of Trials	Av. Yield *cwt per acre*	No. of Trials	Av. Yield *cwt per acre*	
Atle.. ..	28	26·4	5	20·4	23
Atson ..	28	26·6	5	23·3	12
Karn II ..	27	26·6	5	21·2	20
Koga II ..	26	27·9	5	12·6	55
Peko ..	28	27·9	5	16·3	42
Progress ..	10	25·6	4	16·5	36

The worst affected trial was in Devon, where the plots looked very well in early July but the subsequent attack of Black Rust reduced the yields to: Atle, 8·8; Atson, 10·4; Karn II, 9·2; Koga II, 2·4; Peko, 4·1; and Progress, 6·3 cwt per acre. Comparing the yield of Koga II with its average yield in trials where no rust was present, there is a reduction of over 90 per cent. The trials which were badly affected by Black Rust were all in the South-West. Those trials which were not affected were widely scattered over England and Wales. Earlier trials had given no indications of any special regional unsuitability for any of the varieties concerned. In the previous season, Koga II yielded well at various centres, including a trial in Somerset. Peko had also given good yields at a wide range of centres. The poor yields of certain varieties in 1955 is therefore attributed to differences in susceptibility to Black Rust attack. Differences in the extent of the damage were also visible in the field.

Of the varieties in trial, Koga II suffered most at all centres, but Peko was also severely attacked. The variety which was affected least was Atson. Atle and Karn II occupied intermediate positions, while Progress was affected

* Now at Imperial College of Science and Technology, Field Station, Silwood Park, Sunninghill, Berks.

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rather more than these. Alex was also severely affected by the rust, but the yields have been omitted from the table as it was not included in many of the trials. Fylgia, where it was in trial, suffered relatively little damage. Where infection was not present, Koga II and Peko were the highest yielding varieties, but where it was severe, they were the lowest. These differences in susceptibility of varieties were not simply due to differences in the earliness of the varieties, as Karn II, Atson and Koga II, for example, eared in the order given.

In trials of winter wheat varieties, Eclipse and Heines VII appeared to be rather susceptible, while Cappelle Desprez, Hybrid 46, Minister and Redman were not quite as badly affected. Where present in the autumn-sown trials, Atle had less infection, and Atson less still. In demonstration plots at the two N.I.A.B. centres in the South-West, Pilot and King II were more severely affected than a large range of other winter wheats.

No information is available on the identity of the physiologic race (or races) present. Although certain varieties were affected more than others in 1955, it does not necessarily follow that the same varieties would suffer most in another season, as a different race of the rust might be present.

ATTEMPTS IN THE CHEMOTHERAPY OF VIRUS-INFECTED GLASSHOUSE PLANTS

by R. HOWLES

Glasshouse Crops Research Institute, Littlehampton

Recently there have been many attempts in the therapy of virus-infected plants by means of chemical treatment (Locke, 1948; Stoddard and Dimond, 1949; Chamberlain and Fry, 1950 ; Nichols, 1952a). Substances found by these and other workers to have therapeutic powers were included in experiments on glasshouse plants at the Cheshunt Research Station in 1950–56 and the results obtained are summarized here.

TREATMENTS OF TOMATO PLANTS AFTER INOCULATION WITH VIRUSES

In one experiment, groups of tomato plants at the six foliage leaf stage were inoculated either with tomato aucuba mosaic virus or potato virus X. Some groups of plants were then left as controls, some had 100 ml of the chemical solution applied to the soil in place of water, and the foliage of the remaining groups was sprayed with 25 ml of the chemical solution, jaconet discs being fastened round the bases of the stems to prevent the solution from falling on to the soil. There were ten root-system treatments on successive days, and four foliage treatments on alternate days. Treatment began on the day following inoculation. The chemicals tried were: potassium permanganate (0·1 per cent), malachite green (0·025 and 0·00625 per cent), and urea (0·025 per cent) with potassium bicarbonate (0·025 per cent). None of these cured the plants, although malachite green retarded the multiplication of both viruses.

TREATMENTS OF TOMATO PLANTS BEFORE INOCULATION WITH VIRUSES

Another experiment was similar to that described in the last section except that chemical solutions were applied to the soil, at the rate of 100 ml per pot, on each of five successive days just before inoculation. Of the chemicals used, 8-hydroxyquinoline sulphate (0·025 per cent), hydroquinone (0·0125 per cent), and $\frac{1}{128}$ saturated thiazamide had no effect; malachite green (0·025 per cent), and $\frac{1}{2}$ saturated 2-chlorophenoxyacetic acid delayed the appearance of symptoms —Stoddard and Dimond (1949) reported suppression with malachite green—and zinc sulphate (0·025 per cent) had the opposite effect.

TREATMENT OF CHRYSANTHEMUM CUTTINGS INFECTED WITH TOMATO ASPERMY VIRUS

Chrysanthemum cuttings infected with tomato aspermy virus were treated with various chemical solutions which were either applied to the soil in the pot, using 100 ml of solution, or sprayed on to the shoot systems after jaconet discs had been placed round the bases of the stems. Treatment was given on each of one to five days. In an experiment, in which a group of twenty young plants, about 4 inches high, was treated, the plants were tested for virus more than a month later. The test was made by grinding a leaf from each of five plants in about 15 ml of fresh 0·5 per cent sodium sulphite solution and applying the extract to test plants. There were four tests in each experiment, and, where results were promising, each plant was tested three times during six months. The chemical treatments listed in Table 1, with five applications in each instance, had no effect on the virus.

TABLE 1

CHEMICAL TREATMENTS WITHOUT EFFECT ON ASPERMY VIRUS IN CHRYSANTHEMUMS

	Concentration Applied (per cent)	
	To Roots	To Foliage
Thiouracil	0·00098	0·00098
Malachite green	0·025	0·00625
Zinc sulphate	0·025	0·00625
Fluorescein	0·02	0·02
plus potassium bicarbonate..	0·30	0·30
Calcium chloride	0·20	0·20
8-hydroxyquinoline-sulphate ..	0·025	0·025
Hydroquinone	0·0125	0·0125
Thiazamide	0·0166	0·0166
Sulphanilamide	—	0·00415
plus glucose	—	0·00415

Where sulphanilamide plus glucose was applied to the roots at the same concentration as to the foliage, 2 out of 4 groups of 5 plants were found free from virus. This also occurred where one application of 2 : 4-dichlorophenoxyacetic acid at 0·2 per cent was given to the foliage. A single application of a 0·2 per cent solution of this acid to the roots appeared to have some therapeutic power. There was some damage to the shoot system (flagging and distortion) but cuttings from these plants were normal. It was therefore decided to try the effect of root applications of a number of chlorophenoxyacetic acids. The results obtained are given in Table 2. Some had little or no effect; others, notably 3-chlorophenoxyacetic acid, and the ammonium salt of 2:4-dichlorophenoxyacetic acid had some effect, and with both the chemicals the cuttings from the treated plants were normal.

TABLE 2

EFFECT OF SOME CHLORINATED PHENOXYACETIC ACIDS AND THEIR SALTS ON TOMATO ASPERMY VIRUS IN CHRYSANTHEMUMS

Phenoxyacetic Acid	Concentration per cent	No. of Applications	Damage to Plants	No. of Plants Apparently Freed of Virus
2-chloro	0·013	1	None	2 in 20
3-chloro	0·013	1	None	4 in 20
		5	Slight	7 in 80*
4-chloro	½ saturated	1	Slight	4 in 20
	saturated	3	Severe	1 in 20
2:4-dichloro	0·20	1	Severe	2 in 15
ammonium salt ..	0·013	1	Slight	4 in 20
		2	Severe	22 in 40*
diethylamine salt ..	0·013	1	Slight	2 in 20
anilide	½ saturated	1	None	1 in 20
2:5-dichloro	0·013	1	None	3 in 20
2:6-dichloro	0·013	1	Slight	3 in 20
2:4:5-trichloro	½ saturated	1	None	1 in 20
2:4:6-trichloro	½ saturated	1	None	2 in 20

* Plants tested three times.

TREATMENT OF TOMATO AND LETTUCE SEED FROM VIRUS-INFECTED PLANTS

We repeated the procedure of Chamberlain and Fry (1950) for cleaning virus-infected tomato seed by means of hydrochloric acid, but were unable to confirm their claim. The varieties in our experiments were Potentate, E.S. 1, Down's Seedling, Ailsa Craig and Potential.

Various treatments with 2-chlorophenoxyacetic acid were tried on tomato seed which contained only mild tobacco mosaic virus and which had been completely separated and mixed. Treatment of 2 g of the seed with 16 ml of the saturated acid for 6 days, until the seed was almost germinating, reduced the virus to a very small amount. The treated seed was rinsed with water before testing by the half-leaf method. If the seed were dried and then allowed to germinate in water, there was no virus left at incipient germination. The inactivation of the virus was probably due not only to the 2-chlorophenoxyacetic acid, but to some other factor. The percentage of germination was normal, and the seedlings were also normal. The inhibitory effect of hormones on virus multiplication has been demonstrated previously by Locke (1948) and Nichols (1952b).

The effect of treating mosaic-infected lettuce seed with 2-chlorophenoxyacetic acid was also tried. Steeping in a 0·02 per cent solution of the acid for two days was unsuccessful: the seed produced infected seedlings.

REFERENCES

CHAMBERLAIN, E. E. and FRY, P. R. (1950). Influence of Method of Tomato Seed Extraction on Seed Transmission of Tobacco-mosaic and Tomato-streak. *N.Z.J. Sci. Tech.* (*A*), **32**, No. 2, 19–23.

LOCKE, SETH B. (1948). Studies on the Chemotherapy of Potato Virus Diseases. *Phytopathology*, **38**, 916.

NICHOLS, CARL W. (1952a). The Inhibition of Tobacco Mosaic Symptoms by Application of Certain Plant Hormones. *Phytopathology*, **42**, 517.

NICHOLS, CARL W. (1952b). The Retarding Effect of Certain Plant Hormones on Tobacco Mosaic Symptoms. *Phytopathology*, **42**, 579–80.

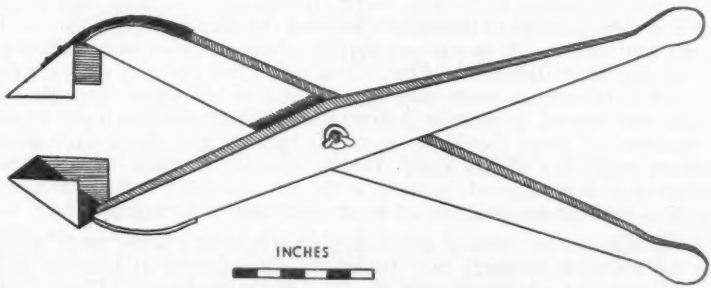
STODDARD, E. M. and DIMOND, A. E. (1949). Malachite Green Suppresses Symptom Expression of Tobacco Mosaic Virus in Tomato. *Phytopathology*, **39**, 24.

A METHOD OF ESTIMATING THE DENSITY OF FRIT FLY EGGS IN THE FIELD

by D. WEBLEY

National Agricultural Advisory Service, Cardiff

The forecasting of Frit fly, *Oscinella frit* L., attacks on oat crops has been based in the past on the work of Cunliffe who, in a series of papers published between 1921 and 1936, dealt with various aspects of the problem (for references see Cunliffe and Hodges, 1946). His method was based upon the number of imagos swept from the crop. This technique suffers from a serious limitation, since it has been shown by Hughes (1955), working with Chloropids, that weather conditions at the time of sampling can account for 30 per cent of female and 60 per cent of the male variances in the logarithm catch. Hughes also pointed out that the behaviour of the female flies under different weather conditions, as reflected in the size of the sweep catch, is much less predictable than that of males. Clearly, if in any study one is interested in the total potential attack on the crop, a rather more accurate estimate is needed. Cunliffe and Hodges (1946) resorted to visual egg counting as a measure of the infestation. When this method was tried out in the field in 1956 it was found that the eggs fell off the plants at the slightest touch, and many were found on the soil, and some even below the soil surface. An accurate count could not be made by this means, and, therefore, a method based on the technique described by Fenwick (1940) for removing *Heterodera* cysts from small soil samples has been developed.



Soil sampling tool for Frit fly egg estimations.

Examination in the field showed that eggs are not laid at random in the soil, but near the plant, and, therefore, the various circular wireworm sampling tools, as described by Cohen (1955), could not be used as it was necessary to sample along the drills, and at a uniform distance to each side. It was also found that such circular samplers gathered soil to an excessive depth without increasing the number of eggs collected. An instrument was designed to sample along the drills taking in 3-inch " bites " of the drill (see figure): each bite, about 100 grammes in weight, covers 9 square inches of soil surface. The tool consists of a shaft in the form of wooden scissors 2½ feet long, to the ends of

which are attached metal scoops. The scoops are 3 inches wide and are so arranged that their cutting edges meet when the arms of the scissors are brought together—a similar action to that of a mechanical grab. The samples are taken by placing the open scissors on the drill at soil level 1½ inches to each side. The handles are then drawn together with a downward pushing movement. The blades meet below the soil surface cutting off the plants at root level. The handles are kept closed until the soil is released into a bag. When testing this tool it was found that increasing the gap between the blades to 7 inches—the full inter-drill width—did not increase the number of eggs collected. The field on which the samples were taken was a medium alluvial loam.

On returning to the laboratory, the undried samples are washed through a Fenwick apparatus and the float is collected in a B.S.I. 100-mesh sieve. The plants are stripped and washed over the 20-mesh sieve of the apparatus to remove any adhering eggs. The plants should be counted at this stage. The float is transferred to a 500 ml conical flask and shaken up with a saturated solution of magnesium sulphate and allowed to settle. The organic matter of the float is then decanted off on to a filter paper and washed with water. The residue left in the flask is topped up with magnesium sulphate and the process repeated. The organic float thus obtained is transferred in portions to a ruled Perspex dish, stirred with a little water, and examined under a low power binocular microscope. The eggs are removed with a small pipette and counted.

EFFICIENCY OF THE METHOD

To test the efficiency of the technique for removing eggs from the soil, the sludge as well as the float was shaken up with saturated magnesium sulphate solution and the organic matter examined. The mean loss of eggs, calculated from those remaining in the sludge, of twenty separate samples, was 2·6 per cent—a figure small enough to be ignored.

To test the technique in the field, some 1/100th-acre trial plots were sampled to see if it were possible to distinguish between the number of eggs laid on two different oat varieties. It was found that five bites per plot were sufficient to show up significant differences. From these results the figure of eggs per plant was found to be more accurate than eggs per unit of drill-length since the stand of plants was uneven. It must be pointed out, however, that both plant counts and numbers of bites should be recorded because the above experimental conditions might not always apply. This is especially the case when the build up of attack is being studied, because, as the attack develops, the total number of plants is reduced by the death of those most heavily damaged.

Egg estimations for second generation panicle attack were made without using the Fenwick eelworm can. Panicles were collected at random in the field and placed in polythene bags. Because of the presence of Cereal thrips, the bags were opened in the laboratory and placed near a source of light to allow the thrip population to escape. The samples were then soaked in a 10 per cent detergent solution. The eggs from the panicles and the liquid were then washed through a 20-mesh sieve on to a 100-mesh sieve with a powerful jet of water. The residue on this sieve was washed on to a filter paper and counted.

The same trial plots were sampled taking 10 panicles per plot. From the results obtained it appears that eggs per panicle was as good a measure of infestation as eggs per spikelet, but in another experiment, where the panicle size was more variable, eggs per spikelet was better. It is recommended that a record should be kept of both the numbers of spikelets and panicles.

Estimating Frit Fly Eggs

Although the wireworm wet method has been used for estimating the density of certain Dipterous eggs (Cohen, 1955), difficulties arise with Frit fly because of the amount of soil and debris present compared with the size of the eggs. It is also very difficult to pick out the eggs without the aid of a binocular microscope. The technique described for estimating the first generation reduces the amount of soil to be sampled to a minimum and consequently the amount of debris to be examined. It is also possible to distinguish between hatched and unhatched eggs.

I should like to record my thanks to Dr. J. H. Fidler for his help in the design of the sampling tool and for his drawing of it, and to the staff of the entomology department at Cardiff for their help.

References

Cohen, M. (1955). Soil Sampling in the National Agricultural Advisory Service. *In* Kevan, D. K. McE. *ed.*, *Soil Zoology*, Butterworths, London, 347–50.

Cunliffe, N. and Hodges, D. J. (1946). Studies on *Oscinella frit* Linn. Notes on the Resistance of Cereals to Infestation. *Ann. appl. Biol.*, **33**, 339–60.

Fenwick, D. W. (1940). Methods for the Recovery and Counting of Cysts of *Heterodera schactii* from Soil. *J. Helminth.*, **18**, 55–72.

Hughes, R. D. (1955). The Influence of the Prevailing Weather on the Numbers of *Meromyza variegata* Meigen (Diptera, Chloropidae) Caught with a Sweepnet. *J. Anim. Ecol.*, **24**, 324–35.

ESTIMATING CROP LOSSES DUE TO WHEAT BULB FLY

by F. Raw and J. R. Lofty

Rothamsted Experimental Station, Harpenden, Herts

When assessing the economic importance of an insect pest, it is necessary to have an accurate estimate of the crop losses caused by it. In practice, such an estimate is extremely difficult to make for it requires an estimate of the extent and intensity of the infestation throughout the area in question and also an estimate of the effect of the varying levels of infestation on crop yield. The former estimate may be obtained by survey, the latter must be based on field experimentation.

The difficulty of establishing levels of infestation experimentally is a serious obstacle to such field experimentation. The usual method is to eliminate the pest from certain plots by means of insecticide (Strickland, 1954), but this method is open to the criticism that the effect of the insecticide may not be limited to the control of the insect under study. Judenko, Johnson and Taylor (1952), studying the effect of bean aphis on yield, painstakingly removed the aphids from their control plots, by hand, each day. Church, Westmacott and Jacob (1956), studying the effect of rabbit grazing on cereals, excluded rabbits by

fencing their control plots. By these methods, when applicable, two levels of infestation were established giving infested plots and controls.

By utilizing the oviposition response of Wheat Bulb fly to certain soil conditions (Raw, 1955) and its habit of ovipositing before the wheat crop is sown, it is possible to establish several levels of infestation experimentally, without using insecticides and without affecting conditions for plant growth. The results of one season's investigations are presented to illustrate the application of this method to the estimation of crop losses. The data were obtained from experiments carried out on Broadbalk and Pennell's Piece—two adjacent fields at Rothamsted.

EXPERIMENT ON BROADBALK

An account of the Broadbalk plots and their infestation with Wheat Bulb fly has already been given (Raw, 1954). In attempting to measure the effect of infestation on yield, five plots (Nos. 2, 3, 5, 7 and 10) were chosen for study, each representing a different manurial treatment as shown in Table 1. Observations were made in the section of each of these plots which was fallowed in

TABLE 1

SUMMARY OF DATA FOR SCREENED AND UNSCREENED STRIPS IN BROADBALK EXPERIMENT

Manurial treatment:	Plot 2 Dung	Plot 3 None	Plot 5 P, K, Na, Mg	Plot 7 N_3, P, K, Na, Mg	Plot 10 N_3	Sig. diff. ($P<0{\cdot}05$)
Plant Counts. April 1955						
No. of plants (000 per acre)						
Screened	1,213	1,223	1,055	709	1,120	
Unscreened	1,101	1,232	1,055	625	756	
Difference	+ 112	− 9	0	+ 84	+ 364	282·5
Percentage infested plants						
Screened	7·0	4·6	3·6	4·0	4·9	
Unscreened	18·3	9·8	18·0	19·5	34·4	
Difference	−11·3	− 5·2	−14·4	−15·5	−29·5	5·0
Percentage infested shoots						
Screened	3·9	3·6	2·6	1·9	3·5	
Unscreened	10·2	6·7	11·5	11·4	26·4	
Difference	− 6·3	− 3·1	− 8·9	− 9·5	−22·9	1·8
Yields (85 per cent Dry Matter). August 1955						
Grain (cwt per acre)						
Screened	45·3	18·6	24·5	33·5	22·0	
Unscreened	40·9	21·0	23·8	37·2	17·7	
Difference	+ 4·4	− 2·4	+ 0·7	− 3·7	+ 4·3	6·9
Straw (cwt per acre)						
Screened	47·8	18·8	23·7	39·4	20·1	
Unscreened	43·3	18·0	20·3	42·3	14·4	
Difference	+ 4·5	+ 0·8	+ 3·4	− 2·9	+ 5·7	7·6
No. of straws (000 per acre)						
Screened	1,438	757	823	1,248	743	
Unscreened	1,269	778	767	1,137	553	
Difference	+ 169	− 21	+ 56	+ 111	+ 190	361·0

Manurial treatments (per acre)

Dung	= 14 tons	K	= 2 cwt sulphate of potash
P	= 3½ cwt superphosphate	Na	= 1 cwt sulphate of soda
N_3	= 4 cwt sulphate of ammonia	Mg	= 1 cwt sulphate of magnesia

1954 and carried the first wheat crop after fallow in 1955. In this section of each plot two pairs of strips were chosen at random. Each pair consisted of one strip which was screened throughout the oviposition period to prevent oviposition, and another, 5 yards away, which remained unscreened. Each strip was 2 yards wide and ran the width of the plot. Plot 2 is 23·3 feet wide and the others are 21 feet wide.

The screens (Plate I, 1) were made from terylene mosquito netting of suitable mesh, with canvas sides, 6 inches deep, buried in the soil at the base. The light intensity under the screens was reduced by about 10–15 per cent but otherwise there was little interference with climatic conditions affecting the plots. In 1954, Wheat Bulb flies began to emerge towards the end of the third week in June and the screens were put in place by the end of the first week in July. They had to be lifted for a few hours on August 18 and again on September 13 to enable the plots to be cultivated to eradicate weeds. The screens were finally removed at the end of September, just before the plots were ploughed. After removing the screens, eight soil samples, each 4 inches in diameter and 6 inches deep, were taken from each screened strip and examined by a standard flotation method for Wheat Bulb fly eggs. No eggs were found so it was concluded that the screens had effectively prevented oviposition.

Broadbalk was ploughed on October 1, 1954 and sown to wheat, Squareheads Master (13/4), at 3 bushels per acre on December 6. In April 1955, plant samples were taken from the screened and unscreened strips to estimate the larval population. Eight samples, each consisting of the plants from a 6-inch length of drill, were taken from each strip. All the shoots were dissected and the numbers of plants, shoots and infested shoots recorded for each sample. At the time of sampling, most of the plants on the plots receiving adequate nutrient had 2–3 tillers but the internodes had not begun to elongate. Most of the larvae were in the second instar though a few were still in the first and some were in the third.

At harvest, a central strip, 3 feet wide, across the full width of the plot was harvested by hand from each strip and the yield of grain, straw and numbers of straws recorded.

The data from plant counts and harvest are summarized in Table 1. The slight infestation of the screened strips may have been caused by larvae migrating from the edges or, more probably, by eggs being carried over with soil during ploughing and subsequent cultivations. Infestation of the screened strips ranged from 9·8 per cent of plants on Plot 3 to 34·4 per cent of plants on Plot 10, and from 6·7 per cent of shoots on Plot 3 to 26·4 per cent of shoots on Plot 10. There is evidence of a reduction of plants in spring on the unscreened strips of Plot 10 but at harvest no significant difference in yield of grain, straw or numbers of straws between screened and unscreened strips was recorded, though Plot 10, which had the heaviest infestation, appeared to be affected most. The data suggest, therefore, that infestations up to about 30 per cent in a crop which has begun to tiller do not affect yield, though it must be remembered that the experimental design, with only two pairs of strips per plot, would not show up small effects.

EXPERIMENT ON PENNELL'S PIECE

The experiment on Pennell's Piece made use of the different levels of infestation established experimentally when studying the oviposition response of

Wheat Bulb flies to certain soil conditions, (Raw, 1955). Three factors applied to fallow during summer 1954 had been studied. They were:

Organic manure: farmyard manure at 15 tons per acre versus no manure.
Tilth: smooth tilth versus rough tilth.
Cultivation: soil cultivated during oviposition period versus no cultivation.

The treatments were arranged factorially giving eight treatment combinations. The experimental layout was a latin rectangle design consisting of 32 plots in a 4 × 8 pattern. Each plot was 5 feet square and there were paths 1 foot 6 inches wide between the plots (Plate I, 2).

In this experiment no effect of farmyard manure on oviposition was observed but the plots with rough tilth had significantly more eggs laid in them than the plots with smooth tilth, and the plots which were cultivated during the oviposition period had significantly more eggs laid in them than the plots which were not cultivated. Consequently four levels of infestation had been established, represented by the treatment combinations: smooth—uncultivated; smooth—cultivated; rough—uncultivated; and rough—cultivated, each of which was represented in the experiments by 8 plots, 4 of which had received a dressing of farmyard manure and 4 of which had not. The experiment therefore provided a means for estimating the effect of different levels of infestation on yield at two levels of fertility—with and without farmyard manure.

The seedbed was prepared by hand in late autumn and the plots and paths were drilled with Cappelle wheat at 3 bushels per acre on December 7, 1954. A basal dressing of compound granular fertilizer (12 per cent N, 12 per cent K_2O, 15 per cent P_2O_5) was combine drilled with the seed at the rate of 150 lb per acre. A top dressing of " Nitro-Chalk ", at 3 cwt per acre, was applied in the spring, on May 9. Larval infestation in the plants was estimated in the same way as on Broadbalk. In April 1955, the plants from eight 6-inch lengths of drill were taken from each plot and the numbers of plants, shoots and infested shoots recorded. At the time of sampling, the plants were not so advanced as on Broadbalk and for the most part were just beginning to tiller. At harvest, the paths were first cut out by hand and the plots harvested individually, the outside rows from each plot being discarded. The yield of grain, straw and number of straws was recorded.

TABLE 2

SUMMARY OF DATA FROM PENNELL'S PIECE EXPERIMENT
(Means of 4 plots)

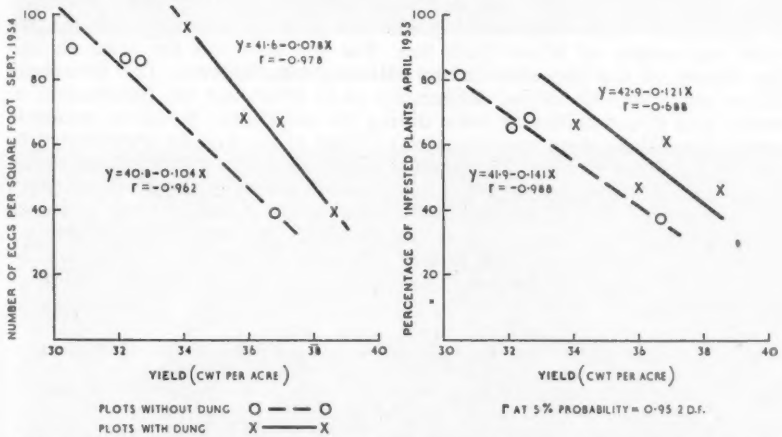
Previous Fallow Treatment	Soil Infestation Eggs/sq. ft Sept. 1954	Plant Infestation per cent April 1955	Grain* cwt/acre	Straw* cwt/acre	No. of Straws thousands/ acre
Plots without dung					
Smooth uncultivated..	38	37	36·7	31·4	1,073
Smooth cultivated ..	86	65	32·1	26·3	915
Rough uncultivated ..	85	68	32·6	27·6	882
Rough cultivated ..	89	81	30·5	26·5	826
		Mean	33·0		
Plots with dung					
Smooth uncultivated..	39	46	38·5	32·6	1,157
Smooth cultivated ..	67	61	36·9	32·3	1,064
Rough uncultivated ..	69	47	35·8	30·4	1,008
Rough cultivated ..	96	66	34·1	27·1	882
		Mean	36·3		

* 85 per cent dry matter.

The data from egg counts in September 1954, plant counts in April 1955 and harvest 1955 are summarized in Table 2 and shown graphically in the figure. The application of dung to the fallow did not affect the infestation but as it had a residual effect on yield the results for the plots which received dung are shown separately from those which did not. The infestation on the groups of plots without dung ranged from 38 to 89 eggs per square foot and 37–81 per cent plants infested and, on the plots with dung, from 39 to 96 eggs per square foot and 46–66 per cent of plants infested, so the experiment covered a wide range of infestation.

The yields of grain corresponding to these infestations ranged from 36·7 to 30·5 cwt per acre on plots without dung and from 38·5 to 34·1 cwt per acre on plots with dung. Yields of straw and numbers of straws per acre showed similar effects. The mean overall response to the dung was an increase of 3·3 cwt of grain per acre. The difference in yield between plots with the heaviest and lightest infestations—6·2 cwt and 4·4 cwt per acre—are of the order of 1½–2 times this response.

The relationship between infestation and yield is clearly shown in the figure, where the regression equations and correlation coefficients are given. Three of the correlation coefficients are significant and although the correlation between plant infestation and yield for the dunged plots fails to reach significance level, the general trend, taken in conjunction with the other data, is evident.


NUMBER OF EGGS PER SQUARE FOOT SEPT. 1954
y = 41·6 − 0·078X
r = −0·978
y = 40·8 − 0·104X
r = −0·962
YIELD (CWT PER ACRE)
PERCENTAGE OF INFESTED PLANTS APRIL 1955
y = 42·9 − 0·121X
r = −0·688
y = 41·9 − 0·141X
r = −0·988
YIELD (CWT PER ACRE)
PLOTS WITHOUT DUNG
PLOTS WITH DUNG
r AT 5% PROBABILITY = 0·95 2 D.F.

Relationship between yield of grain and Wheat Bulb fly infestation. Pennell's Piece, 1955.

The method of threshing undoubtedly contributed to the high grain : straw ratio recorded in both experiments but more especially in Pennell's Piece where the short-strawed variety Cappelle was sown. A hand threshing machine was used which recovered all the grain and long straw satisfactorily but lost most of the chaff and some of the short straw. This method gave consistent results which are strictly comparable for the two experiments. However, the use of special methods for harvesting, storing and threshing the produce from the experiments invalidates a strict comparison between the yield of the unscreened strips of Broadbalk and the yield recorded by the farm for the whole plots by conventional harvesting methods.

DISCUSSION

The purpose of the paper was to illustrate an experimental method for estimating crop losses due to Wheat Bulb fly. The Pennell's Piece experiment made use of infestations established in the previous fallow by varying certain soil conditions. Unfortunately, for the present purpose, this did not include a screening treatment used successfully on Broadbalk to prevent oviposition. A screening treatment combined with soil treatments would clearly provide a method for studying the effect of infestation on yield over a wide range of infestations including uninfested controls. In this way, also, the effect of such factors as soil fertility, date of sowing, variety and tillering capacity in relation to infestation and yield could be investigated.

Clearly no general conclusions should be drawn from one season's experiments of this kind. It is, however, interesting to note the satisfactory yield of 30·5 cwt per acre from the 4 plots without dung of which 81 per cent of the plants were infested in April when tillering was just beginning. An infestation of that order, at that time, might well have been associated with a crop failure, and the results suggest that there is a fairly critical balance between crop failure and crop recovery which merits full investigation.

It is also interesting to compare the infestation of the Broadbalk plots with that of Pennell's Piece. The Broadbalk fallow and the Pennell's Piece experiment were about 50 yards apart, separated by an unfenced farm road and that section of Broadbalk which was carrying the first crop after fallow and so provided the source of Wheat Bulb flies. The soil type was the same though the history of the two sites before fallowing was different. The Broadbalk fallow was a smooth fallow, deliberately so to encourage the germination of weeds, and it was cultivated twice during the oviposition period to eradicate weeds. Conditions there approximated to those of the smooth-uncultivated or smooth-cultivated plots on Pennell's Piece. However, the overall infestation on Broadbalk, measured by the plant infestation in spring (mean 20·0 per cent), was about half that of the lightest infestation on Pennell's Piece (smooth-uncultivated plots: 37 per cent). Evidently, within the limited area of the two experiments, some factor or factors operated to produce differences in infestation of at least the same order as any produced experimentally on Pennell's Piece.

We are indebted to G. V. Dyke for advice on management and to the Botany Department for use of the hand threshing machine. R. M. Dobson and J. W. Stephenson helped with the plant samples and at harvest and J. H. A. Dunwoody kindly undertook the statistical analysis.

REFERENCES

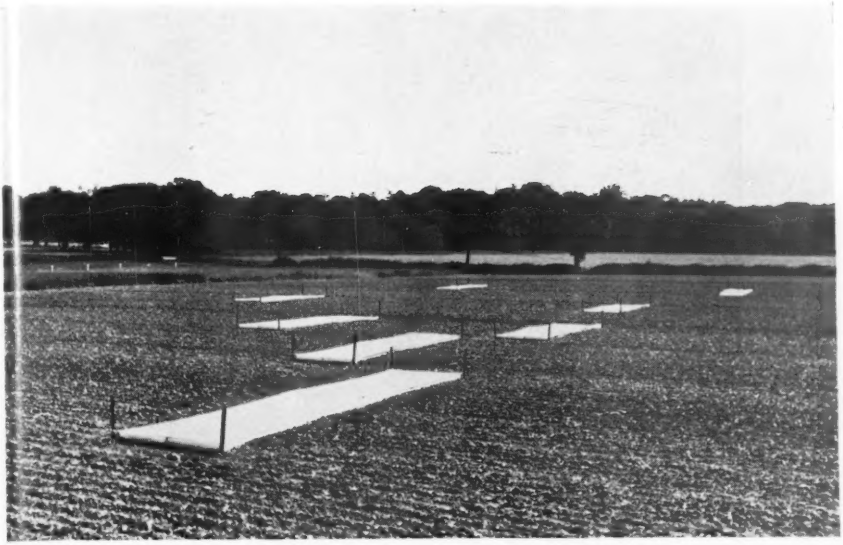
CHURCH, B. M., WESTMACOTT, M. H. and JACOB, F. H. (1956). Survey of Rabbit Damage to Winter Cereals 1953–54. *Plant Pathology*, **5**, 66–9.

JUDENKO, E., JOHNSON, C. G. and TAYLOR, L. R. (1952). The Effect of *Aphis fabae* Scop. on the Growth and Yield of Field Beans in a Garden Plot. *Plant Pathology*, **1**, 60–3.

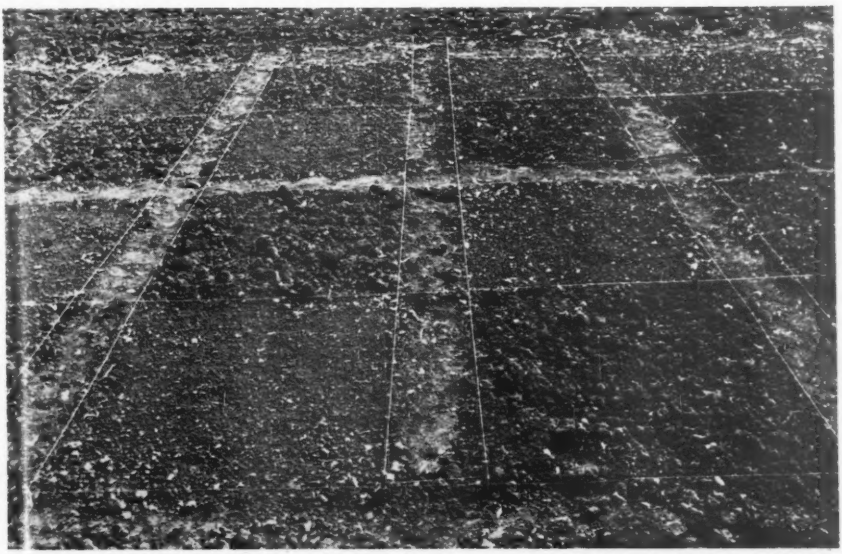
RAW, F. (1954). Observations on Wheat Bulb Fly Infestation of Broadbalk Wheat Plots. *Plant Pathology*, **3**, 134–7.

RAW, F. (1955). The Effect of Soil Conditions on Wheat Bulb Fly Oviposition. *Plant Pathology*, **4**, 114–7.

STRICKLAND, A. H. (1954). Assessment of Cabbage Aphid Damage in Commercial Brussels Sprout Crops. *Plant Pathology*, **3**, 107–17.



1. Broadbalk fallow, 1954, showing screened strips.



Photos: Rothamsted Experimental Station

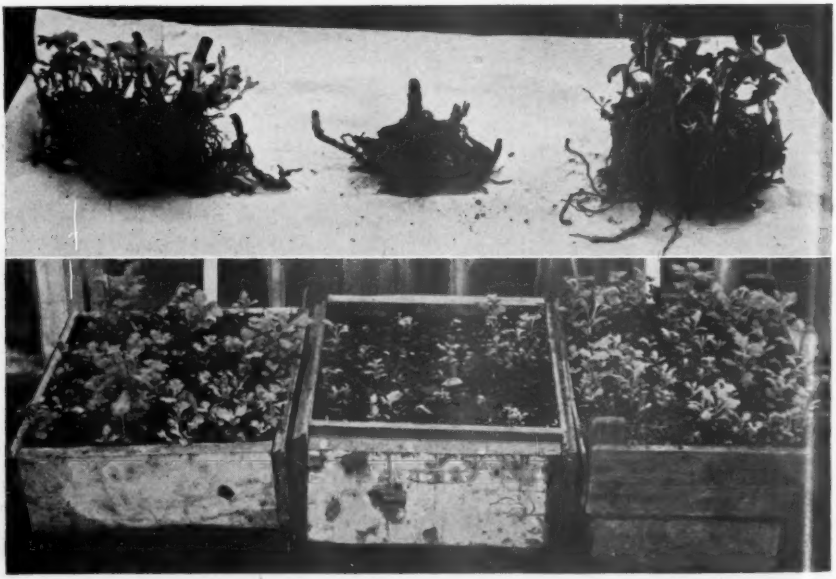
2. Pennell's Piece, 1954, showing rough and smooth plots.

PLATE I

RHABDITID EELWORMS IN MUSHROOM BEDS (*see pp. 61–2*)

1. *Left :* Single larvae and massed " swarming " larvae. X 9
Right : A single mass of about 100 swarming larvae. X 50

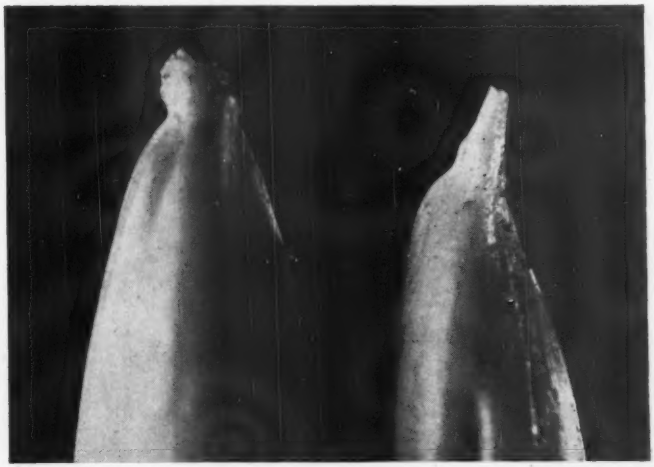
CONTROL OF CHRYSANTHEMUM STOOL MINER (*see pp. 64–5*)



DIELDRIN CONTROL BHC

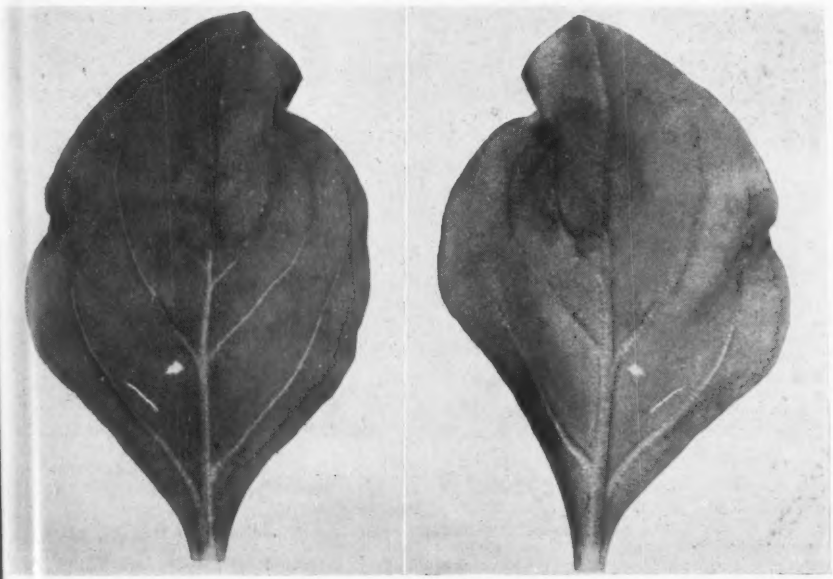
2. Typical stools and boxes (*variety :* J. M. Painter) on January 30, 1956, showing effects of treatments. Fifty cuttings had already been removed from the dieldrin box.

FRIT FLY AND THE OAT PANICLE (*see pp. 66–74*)



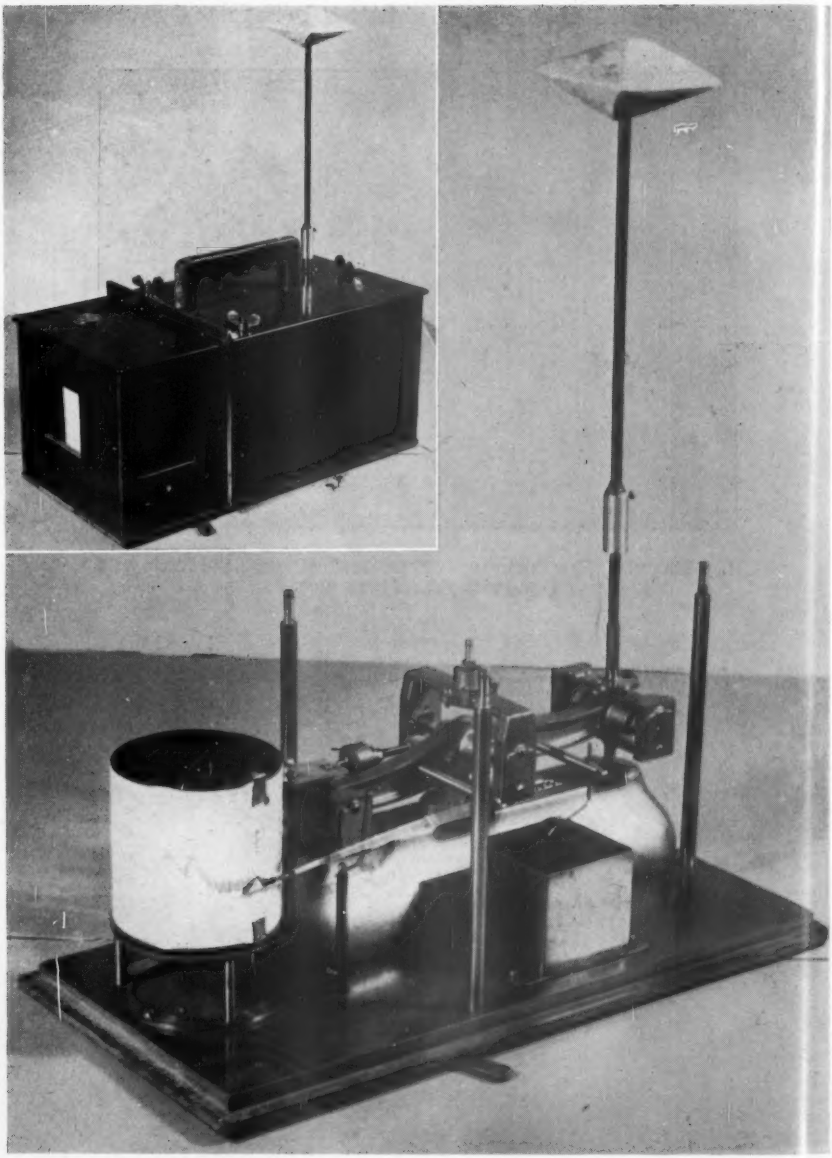
1. Main grain (*left*) with truncated connection after fracture, and bosom grain (*right*) with pointed connection.

PHYTOPHTHORA INFESTANS ON *PETUNIA HYBRIDA* (*see p. 76*)



2. Lesions on a petunia leaf from a garden in Harpenden, August, 1956. *Left :* Upper leaf surface. *Right :* Lower leaf surface.

PLATE III



Photos: Rothamsted Experimental Station

Instrument with cover removed, showing beam supporting polystyrene test surface on right ; counterbalance and recording drum, left ; and oil damping tank, centre. *Inset :* **instrument with cover in place.**

PLATE IV

A SIMPLIFIED SURFACE-WETNESS RECORDER

by J. M. HIRST

Rothamsted Experimental Station, Harpenden, Herts

The length of time plant surfaces remain wet is important in determining whether the spores of many plant pathogenic fungi can germinate and grow enough to penetrate their host plants. The dew balance described by Hirst (1954) has been used successfully as a research tool to measure these periods and to determine the infection requirements of the fungi that cause Potato Blight and Apple Scab. Living shoots were used on this balance, because it was essential to know that the measurements were applicable to the leaves being studied. However, this complicated the design and operation of the instrument too much for it to be recommended for the routine determinations of the duration of leaf-wetness, which are needed for the timing of effective curative sprays against Apple Scab. Such a research instrument provides a standard for comparing living shoots with other test surfaces. The present paper describes an instrument that simulates apple shoots. To avoid confusion, the earlier type of instrument using live shoots will hereafter be referred to as the " dew balance " and the later modification described in this paper will be called a " surface-wetness recorder ".

The material for a non-living test surface must be such that it is wetted and dries at almost the same times as the leaves of the crop being studied. For routine use the instrument must be cheap, simple and robust, and must not require electric power or frequent skilled maintenance. Jointly with Mr. J. Macdowall, such an instrument was designed and subsequently made in the Meteorological Office workshops, and its behaviour tested and compared with that of a dew balance fitted with either apple or potato shoots.

CONSTRUCTION OF THE INSTRUMENT

After preliminary tests it was decided not to use spring or flotation balances but to retain a beam of similar pattern (W. and T. Avery Ltd. Type 2014) to that used in the dew balance. Plate IV shows the test surface, a block of expanded polystyrene cut to a tetrahedral shape, at the top of a ¼-inch diameter rod, the bottom of which is fitted in a vertical supporting tube fixed to the right-hand end-bracket of the beam. An arm carrying a paddle immersed in a small oil-filled tank in front of the beam reduces the oscillation of the beam caused by wind. In the rear, adjustable counter-balance weights can be seen on an arm fitted to the centre of the beam. When the test surface is dry, these are set so that the left-hand side of the beam is depressed to nearly the full extent. A pen swung from the left-hand side of the beam records changes in the equilibrium of the beam on daily charts placed on the rotating drum at the left of the instrument. The traces produced (Fig. 1) resemble those from the dew balance (Hirst, 1954).

The omission of the shoot and its water supply, together with the use of a smaller clock, allow the size of the instrument to be reduced and simplify the design of a protective housing. The cover is in two parts (Plate IV inset) and only the left-hand section need be removed each day to change the chart and

refill the pen; windows allow the trace to be examined without uncovering. The right-hand section, fitted with a carrying handle, is fixed by wing-nuts to three tie-rods attached to the base-board. The $\frac{1}{4}$-inch diameter rod carrying the test surface moves freely through a larger erect tube fixed to the top cover. A shrouding sleeve, the top of which is fitted closely to the rod while its lower part freely overlaps the fixed erect tube, prevents water getting in.

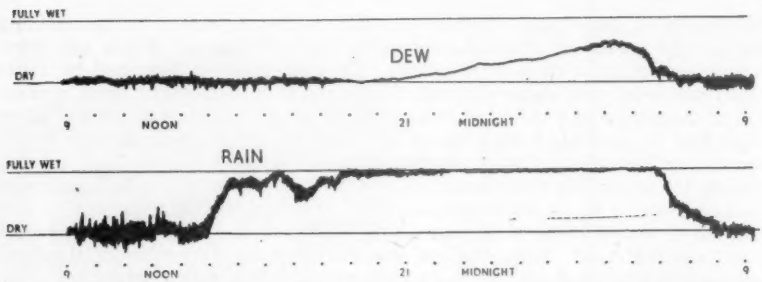


Fig. 1. Traces from surface-wetness recorder (above) for partial wetting by dew in calm period at night, June 2, 1956, and (below) for heavy wetting by rain, May 10, 1956.

The surface-wetness recorder was intended to record only the duration of wetness. The maximum weight of water deposited was unimportant and there was no need to reduce the sensitivity of the beam as in the dew balance. This improved the clarity and precision with which the times of wetting and drying were indicated. The blocks of expanded polystyrene are easily shaped with a saw or penknife. The upper and lower surfaces were sloped gently to prevent the accumulation of water on the top and to equalize upward and downward wind thrusts. After a few weeks the upper surface of the blocks becomes slightly eroded; although this did not seem to affect responses, new blocks were fitted at monthly intervals.

COMPARISON WITH APPLE FOLIAGE

The periods when either the apple shoot on the dew balance, or the expanded polystyrene of the surface-wetness recorder, were wet for more than one hour and less than 25 hours, are shown in Fig. 2. The periods are separated into two categories:

Partial wetting. When either beam was visibly deflected, up to but not including times when the beam of the surface-wetness recorder was fully deflected. These comprise such weather as slight showers, drizzle and dew (Fig. 1).

Heavy wetting. Defined by full deflection of the surface-wetness recorder beam for part of the period. These comprise only the heaviest dews and rain to run-off (Fig. 1).

Tests were made between April 17 and June 19, 1956 (Fig. 2) in the Bramley's Seedling orchard at Wisbech where the epidemiology of Apple Scab was being studied (Hirst *et al.*, 1955). Both instruments were placed midway between two rows of trees, with their respective surfaces centred at 2 m above ground. New apple shoots were fitted to the dew balance about every fortnight; their surface area varied with individual shoots and also increased through the season as the leaves expanded and the shoots grew longer.

Surface-wetness Recorder

Early in this series there was little rain but nights with dew were common; rainy days became more common later. Fig. 2 shows that the two instruments agreed to within $\pm$ 1 hour on all except a few occasions, none of which was of heavy wetting. The larger discrepancies occurred in the very early stages of dew formation, perhaps because of transpiration by the leaf or because of the larger receptive surface of the shoots, which may have more than compensated for the greater sensitivity of the surface-wetness recorder.

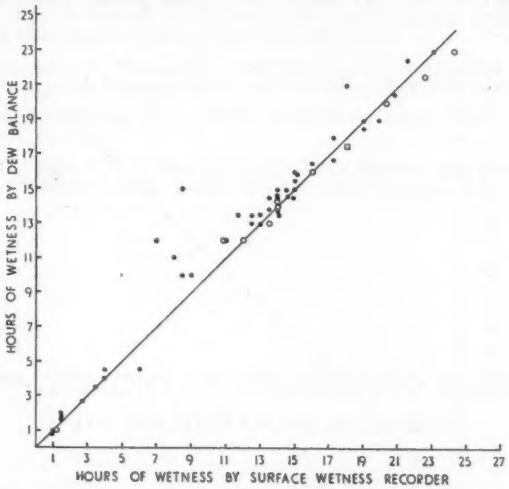


Fig. 2. Hours of wetness recorded by dew balance with apple shoot and by surface-wetness recorder in orchard.
o = heavy wetting • = partial wetting

During a second series of comparisons with apple foliage, at Harpenden over the period June 29 to August 10, 1956, the test surfaces were at the same height as before but were not sheltered by surrounding trees. Exceptionally high winds for the time of year were frequent and interfered with the efficiency of the dew balance, causing excessive oscillation of the beam and damage to the leaves. During the period there was much rain but only a few nights with dew. Records from the two instruments agreed closely except for one occasion when the dew balance recorded a period 2·4 hours shorter than the surface-wetness recorder. This discrepancy accompanied very slow drying throughout the night, which rarely occurs.

Comparison with Potato Foliage

Between August 17 and September 3, 1956, both instruments were placed in pits in a potato crop at Harpenden. The base of the shoot installed in the dew balance was level with those of crop plants but the upper leaves projected above the surrounding foliage, which had been prostrated by gales in late July. The plastic test surface was centred six inches above the crests of the potato ridges.

Again there was much rain and high wind, but there were several calm nights with dew. The wet periods were divided into the same two categories

as were used for the comparison with apple foliage, but the two instruments agreed less closely. The dew balance consistently indicated shorter periods on all except windy days. The differences occurred during drying, when inspection showed that the test shoot dried considerably earlier than the lower leaves of the crop. The surface-wetness recorder was more representative of lower parts of the crop. The errors, which may have been large enough to be important in affecting the behaviour of pathogens, probably result from the difficulty of giving the test shoot a typical exposure in this crop. It is possible, however, that the plastic surface may dry more slowly than potato leaves when similarly exposed.

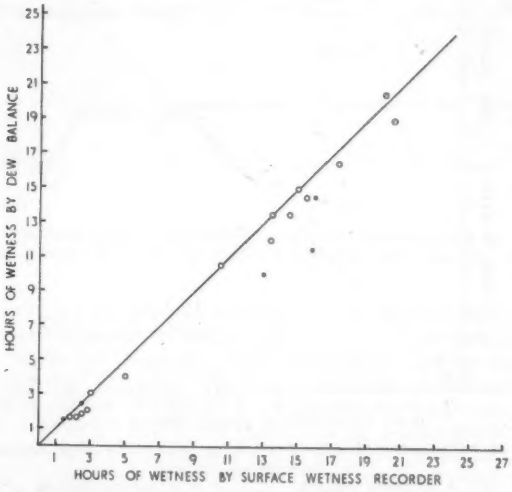


Fig. 3. Hours of wetness recorded by dew balance with potato shoot and by surface-wetness recorder in crop.
o = heavy wetting • = partial wetting

DISCUSSION

The surface-wetness recorder was designed to measure the length of time apple leaves were wet, so that the methods of detecting infection proposed by Mills and LaPlante (1951) might be tested and used to time the application of curative fungicidal sprays against Apple Scab (Storey and Ives, 1956). The records from the dew balance and surface-wetness recorder agree to within $\pm$ 1 hour on almost all occasions except during the very early stages of dew formation. The small deposits at this time are probably insufficient to disperse many spores of *Venturia inaequalis* or to allow them to germinate and grow. The method seems practical, for it is essential to err on the side of caution when conditions may just allow infection. It is advisable, therefore, to make an allowance for local variations in surface-wetness larger than the differences commonly found between the two instruments.

It would not be safe to assume, without further tests, that the surface used would simulate the leaves of other plants as accurately as those of apple, or that its present sensitivity in detecting slight deposits would be sufficient for all pathogens. Much could be done to match test surfaces to a particular type

of leaf by careful choice or treatment of materials, and sensitivity could be increased by using larger test surfaces.

Thanks are due to the Director of the Meteorological Office and Mr. J. Macdowall, who is at present at the Royal Society Base in the Antarctic, for help in the design and construction of the surface-wetness recorder, and to Mr. O. J. Stedman and Mr. W. C. Ward for help in maintaining the instruments.

REFERENCES

HIRST, J. M. (1954). A Method for Recording the Formation and Persistance of Water Deposits on Plant Shoots. *Quart. J.R.met.Soc.*, **80**, 227–31.

HIRST, J. M., STOREY, I. F., WARD, W. C. and WILCOX, H. J. (1955). The Origin of Apple Scab Epidemics in the Wisbech Area in 1953 and 1954. *Plant Pathology*, **4**, 91–6.

MILLS, W. D. and LAPLANTE, A. A. (1951). Diseases and Insects in the Orchard. *Cornell Ext. Bull.* No. 711, 21–7.

STOREY, I. F. and IVES, J. V. (1956). Spraying Practice Against Apple Scab on Bramley's Seedling in the Wisbech Area, in 1953 and 1954. *Plant Pathology*, **5**, 1–8.

THE SWARMING OF RHABDITID EELWORMS IN MUSHROOM HOUSES

by L. N. STANILAND

National Agricultural Advisory Service, Bristol

A phenomenon, which is perhaps best described as swarming, has been observed on several occasions recently in mushroom houses in Dorset. Vast numbers of Rhabditid eelworms have been observed on the surface of the peat casing, the nematodes being grouped into club-like masses containing up to about 100 individuals. Grouped thus, they are easily seen with the naked eye. Viewed by electric light in a dark mushroom house, the surface of the peat casing presents an astonishing sight with the numerous moving and glittering masses of eelworms.

Bovien (1937) has worked on the attachment of larvae of *Rhabditis* sp. to the bodies of Psychodid flies which breed in cow dung, and T. Goodey (1943) has recorded similar transport of the eelworms by flies breeding in sewage beds.

Samples of infested compost were sent to J. B. Goodey, at Rothamsted, who confirmed the eelworms as *Rhabditis* sp. but was unable to make a specific determination. He reported that no males could be found in the samples, though there were plenty of females containing developing eggs, and he concluded that the species might be parthenogenetic. He has also informed me that some species of *Rhabditis* and *Diplogaster*, which infest rotting habitats, multiply enormously and presumably consume all the available bacteria so that overpopulation phenomena ensue. Larvae of the latest generations develop to the third stage and then become what the German writers call "dauer", or resting, larvae, which are able to resist unfavourable conditions. In some circumstances the larvae

will swarm, and in that state they apparently wait for flies and other small organisms to pass over the area. The mushroom houses visited in the present work have been very free from flies, but mites from infested compost have been found bearing eelworm larvae. *Rhabditis* spp. are generally considered to be bacterial feeders, and Hirschmann (1952) has shown that the protein of living bacteria is essential for reproduction.

The relationship between the eelworms and the mushroom mycelium was not clear. Although both J. B. Goodey and I have failed to establish a connection between them and yield, it does seem plain that composts heavily infested with bacteria are those which give the greatest numbers of Rhabditids.

In the present work it was found that the eelworms most frequently swarmed near doors or electric lights. Light stimuli were found to be potent initiators of the swarming habit. When peat casing, heavily infested with hydra-like masses of swarming Rhabditids, was kept moist and in the dark, it was found that the nematodes soon disappeared from the surface. But when the casing was subsequently exposed to bright sunlight, or electric light, signs of eelworm activity were apparent after a few minutes and the swarming process could be observed. Shortly after such exposure to light, the heads of individual larvae could be seen raised in the air and a second eelworm would then wriggle alongside one of these individuals and the two together would be able to raise a greater proportion of their lengths in the air. This process was repeated until a large number of the nematodes had formed the hydra-like masses, and the greater part of their lengths was waving about in the air above the surface of the peat. The whole process took 20–30 minutes to complete and could be controlled at will by switching the light on or off.

The eelworm masses reacted very strongly to tactile stimuli. When touched with a needle the masses collapsed and individuals adhered to the needle. Touching with a finger had the same effect and there is little doubt that the hands of workers picking mushrooms and trimming the beds are an important source of dispersal from bed to bed and house to house.

Composting was found to kill many, but not all, of the eelworms. Peak heating of compost after it had been moved into the house was consistently found to give a complete kill, as was peak heating of old compost before removal from the house. Yet houses very frequently became infested within a week or two after peak heating. The ease with which the eelworms can be spread to fresh habitats seems to be the only explanation for this rapid reinfestation.

The swarming process is illustrated in Plate II, 1. I am indebted to Mr. J. Mayor for the photographs which, because of the continuous flickering movements of the eelworm masses, had to be taken by electronic flash. The mass shown in the right-hand part of the plate was later found to contain nearly 100 larvae. The water lying between and around the larvae was heavily contaminated with bacteria which would certainly be dispersed to new habitats at the same time as the eelworms.

REFERENCES

BOVIEN, P. (1937). Some Types of Association between Nematodes and Insects. *Vidensk. Medd. dansk naturh. Foren. Kbh.*, **101**, 1–114.

GOODEY, T. (1943). On *Rhabditis curvicaudata* (Schniedee) and *R. paraciliata* n.sp. *J. Helminth.*, **21**, 10–7.

HIRSCHMANN, H. (1952). Die Nematoden der Wassergranze mittlefrankishen Gewasser. *Zool. Jb.*, **81**, 313–436.

AN OBSERVATION ON THE CONTROL OF STRAWBERRY MILDEW

by J. INGRAM

Luddington Experimental Horticulture Station, Warwickshire

AND

ELIZABETH R. SCHOFIELD AND R. ERIC TAYLOR*

National Agricultural Advisory Service, Evesham

Strawberry trials at Luddington have been complicated hitherto by the poor control of Powdery Mildew, *Sphaerotheca humuli* (D.C.) Burr., afforded by the sulphur fungicides. Simple observation plots were laid down in 1956 to find a promising alternative. The three-year-old plantation of Royal Sovereign, on which the observations were made, had been used previously, in 1955, for a trial requiring applications of captan and thiram. Neither material appeared to affect the incidence of mildew, and the whole plantation was sprayed once after harvest with 2 per cent lime sulphur. The treatments used in 1956 were:

A. Dinitrocaprylphenyl crotonate: 1 lb of a 25 per cent wettable powder and 7 fluid ounces of a proprietary wetting agent (containing 60 per cent sodium dioctyl sulphosuccinate) in 100 gallons water.

B. Lime sulphur: 2 per cent for the first, and 1 per cent for subsequent applications.

C. Sulphur dust.

D. Griseofulvin (wettable powder formulation) 0·1 per cent.

E. Unsprayed.

The plots comprised five adjacent strips across the plantation; two were left unsprayed, and one used for each of treatments A, B and C. Treatment D was confined to eight groups of five plants selected at random in the unsprayed plots, but plots for A, B and C contained 8, 8 and 3 rows respectively. Treatments A and B were applied by a spray boom attached to a power sprayer with three nozzles covering each row, C with a rotary fan blower, and D with a knapsack sprayer. Wet sprays were applied at the rate of 200 gallons per acre, and sulphur dust at 40 lb per acre. Five applications were made at fortnightly intervals commencing on April 19.

Mildew was first observed on June 6 on one leaf in an untreated plot. The disease thereafter developed rapidly on leaves and fruit in the two untreated plots so that by the end of June they could readily be distinguished from treated areas by their leaf curling and reddish discoloration. Throughout picking, from June 28 to July 18, mildew assessments were made on fruit from eight separate groups of six plants chosen at random from the centre four rows in plots A, B and untreated controls, and from six groups of six plants in plot C. Assessments for treatment D were based on mildewed berries from three plants in each plot. The fruits were classified as "sound", "mildewed", "affected with *Botrytis*", and "otherwise damaged". The results are summarized in the table, and are based on the fruit picked from 48 plants. Records from plot C (36 plants) and D (24 plants) have been adjusted accordingly.

* Now at Trawscoed, Aberystwyth.

Treatment	Numerical Analysis of Berries Harvested—on the Basis of Yield from 48 Plants in Each Treatment				Mildewed Fruits *per cent*
	Sound	Mildew	*Botrytis*	Damaged	
A. Dinitrocaprylphenyl crotonate + wetter	1,958	42	18	284	1·8
B. Lime sulphur	2,472	212	55	346	6·9
C. Sulphur dust	2,674	298	121	460	8·4
D. Griseofulvin	1,202	3,126	54	140	69·1
E. Unsprayed	993	2,295	80	207	64·2

Outstandingly good control of mildew was given by dinitrocaprylphenyl crotonate, and the foliage remained vigorous and dark green throughout the season. The sulphur treatments gave moderately good control, but with some indication of damage to the foliage from lime sulphur. The additional cost of the dinitrocaprylphenyl crotonate programme (£11 8*s*. per acre compared with £2 6*s*. for lime sulphur, and £1 4*s*. for sulphur dust) was more than recovered in the increased returns for the better quality and greater proportion of saleable fruit. These preliminary findings are subject to confirmation by critical trial in 1957. Aspects that need investigation include the timing and number of applications of dinitrocaprylphenyl crotonate required for good commercial control, the residual effects of spraying on yields, and possible effects on quality and flavour of processed fruit.

CONTROL OF CHRYSANTHEMUM STOOL MINER

by W. H. GOLIGHTLY AND N. FRENCH

National Agricultural Advisory Service, Newcastle-upon-Tyne

Damage by the Chrysanthemum Stool Miner, *Psila nigricornis* Meig., both to cuttings and to lettuce following chrysanthemums, appears to be increasing and becoming more widespread. The number of cases of damage appearing in the Monthly Reports of the Advisory Entomologists has doubled since the war compared with a similar pre-war period. In the northern counties, chrysanthemum-cutting production has been seriously affected on some nurseries during the last 4–5 years, and requests from growers showed that investigation into the control of this pest was highly desirable.

As outbreaks appear to be rather spasmodic in appearance, and often unsuspected until shoots on boxed stools begin to wilt in the autumn, it was felt desirable to investigate means of killing the larvae within the plant root system. Trials were conducted to this end during the winters of 1953–54 and 1954–55. It was realized, however, that this method is but a palliative, and prevention of attacks by controlling adult flies during the summer was aimed at in 1955. As some nurseries suffer each year from attack, it was felt that preventative measures, as compared with curative, might well be used in such circumstances.

Chrysanthemum Stool Miner

Control of existing infestations, 1953–54 and 1954–55

In December 1953, pilot trials indicated that schradan and mazidox, when watered on to boxed infested stools, gave some degree of control, but that parathion and corrosive sublimate (an old suggested remedy) were of little use. The mazidox, however, produced marked phytotoxic symptoms and killed an appreciable number of plants.

In 1954, the investigation was repeated on a larger scale using schradan at 0·3 per cent and metasystox at 0·1 per cent. On December 2, these were watered on to boxed infested stools of early-flowering varieties at approximately ¼ pint per stool. The efficiency of the treatments was assessed in February 1955 by recovering puparia and/or larvae from the test stools and soil. The following results were obtained:

Treatment	Number of Stools	Puparia per Stool	Percentage Reduction
Control	64	7·6	0
Schradan	56	2·8	63
Metasystox	57	0·9	89

Despite the heavy initial attack, recovery was most marked following treatment, and stools began throwing fresh sound shoots immediately. As a result of the treatments, sufficient cuttings were obtained to grow on the varieties, whereas practically none was obtained from the untreated stools.

Prevention of attacks

In 1955, 0·05 per cent dieldrin and 0·01 per cent *gamma*-BHC were applied by knapsack sprayer round the bases of plants to test and compare their efficiency in preventing attacks by *Psila nigricornis*. Two applications were made, on August 9 and September 12, at approximately 1 gallon of diluted wash per 100 plants on each occasion.

In mid-December, 20 stools (variety New Princess) from each of the three treatments were examined, and 13, 61 and 91 per cent, from the control, BHC and dieldrin treatments, respectively, were found to be free from attack. The number of shoots produced also varied, there being an average of 4 per stool on the controls, 7·8 on the BHC treated, and 10·8 on those treated with dieldrin.

Final assessments were made early in March on several other varieties, when 217 puparia were recovered from 86 untreated stools, 98 from 144 stools treated with BHC sprays and 7 from 130 stools sprayed with dieldrin. Thus, dieldrin reduced infestation by 98 per cent.

Throughout the winter months, cuttings were taken in succession and the numbers from each treatment recorded. A total of 319 cuttings were taken from 121 untreated stools, 1031 from 156 stools treated with BHC, and 1473 from 143 stools treated with dieldrin, the latter being an increase of nearly 300 per cent over the controls. Typical boxes and stools on January 30, 1956, are illustrated in Plate II, 2.

It would seem that there is considerable promise of adequate control of the Chrysanthemum Stool Miner in both preventing attacks, and controlling them quickly after damage appears following the transfer of the stools to boxes for cutting production. On flower nurseries where this pest is in evidence every year, spraying with dieldrin during August and September will largely prevent attacks developing. Where infestations occur and are not suspected by growers until shoot production is affected during the autumn and winter, considerable relief is given by relatively high dosage rates of either schradan or metasystox.

FRIT FLY AND THE OAT PANICLE

I. THE HEALTHY PANICLE

by D. W. EMPSON

National Agricultural Advisory Service, Wolverhampton

Since 1945, Frit fly, *Oscinella frit* Linn., has been the subject of particular study by the N.A.A.S. Advisory Entomologists in England and Wales (Thomas, 1954). The present work is an attempt to shed light on three questions that have a bearing on the damage caused by the second generation of this pest. Does Frit fly attack on one grain lead to increased growth of adjacent unattacked grains? Does the attack tend to fall on grains that differ in size from the average for the crop? What is the difference in weight and chemical composition between attacked and healthy grains?

The pathology of a plant can only be fully understood when the properties of healthy specimens are known: therefore, this paper first examines, in detail, the relationships between the various parts of the oat panicle not damaged by Frit fly. Berry (1920), and Hutchinson *et al.* (1952, 1953) have shown relationships between the numbers of grains in the spikelet, the grain weight and the kernel content, but the influence of position within the panicle does not seem to have been measured. Zinn and Surface (1917), however, refer to "the well-known fact that the heaviest kernels in the oat panicle are borne near the top of the head and at the tips of the whorls". They also state that "the lightest kernels are found at the base of the whorls and of the panicle, where sterility of the flowers quite often occurs". The greater part of the published work on analysis of oat grains has been carried out on threshed samples: these can give little information of the type required here.

DEFINITION OF TERMS

Various terms have been used by different authors to describe parts of the panicle and conditions of the grain. In this paper the meanings of the terms used are defined as follows. *The panicle* consists of a number of nodes each bearing one or more branches. The branches arising at any node constitute a *whorl;* the whorls are numbered from the apex to the base so that "whorl No. 1" is the single spikelet at the apex of the panicle. *Grains* are divided into *husk* (inner and outer pales of Armstrong, 1937), and *kernel* (caryopsis). Grains may be healthy, damaged, "fritted", or "blind". *Healthy grains* show no sign of attack by insects or fungi, are fully formed, even if small, are ripe and show no major areas of discoloration. *Damaged grains* are those which, while not healthy, are neither "fritted" nor "blind"; they include grain damaged, for example, by birds, and also some grains showing blackening of the embryo and surrounding tissue, similar to that described by Hutchinson *et al.* (1954). Damaged grains have been excluded from observations on grain weight, but normally these have been few in number.

"*Fritted*" *grains* are those which are associated with Frit fly puparia or which appear similar to those known to have been attacked by Frit larvae. Between 80 and 90 per cent of grains classed as fritted contained puparia. "*Blind*" *grains* are those in which there is no indication of external damage to the kernels, and, in particular, no discoloration, but in which the kernels have not developed

beyond a maximum length of one quarter of that of a healthy kernel. The appearance suggests that the cause might be a lack, or failure, of fertilization. The relationship, in weight, between husk and kernel is expressed as the *kernel content*, or *percentage K*, and is equal to: (wt kernel/wt whole grain) $\times$ 100.

In sampling from growing crops the panicles have been taken at random. Before detailed examination, however, any panicles showing damage, deformity, or any shedding of grain, together with those not fully ripe, have been discarded. During three seasons' work (1953–55) less than 1 per cent of damaged panicles was found. In 1956, however, many damaged panicles were seen and this may have been associated with an abnormally high density of first generation Frit fly. Panicles from which one or more grains had been shed never exceeded 5 per cent in this work, but here there may have been a slight bias introduced as shedding is characteristic of completely mature panicles.

Spikelets are classified according to the number of grains in them. *Sterile spikelets* are those with no grains, or with only ill-formed florets within the glumes. This condition, when extensive, is known as *blast*, or blindness by some authors, and I regard it as the expression of a lower potential at the time of floret development than that obtaining at the time of the laying down of the spikelet primordia. *Singles* are spikelets with only one grain, this being classed as a *main grain*. *Doubles* have two grains, a main grain, and a *bosom grain* above it. *Trebles* have three grains, a main grain with second and third grains above it. The latter are both classed as bosom grains. If main and bosom grains are defined in this way the two classes can be separated by examining the point of attachment to the rest of the plant (the basilar connection). In main grains, the connection after fracture is truncate, whereas in bosom grains it is more pointed (Plate III, 1). This difference was well marked in all the samples examined, and enables main and bosom grains to be separated after threshing.

All the crops from which samples were taken were spring sown.

THE OAT PANICLE

In most of the samples examined, the majority of the spikelets had two grains, the following count from a crop of Onward oats in 1953 being typical: singles: 359; doubles: 9,290; trebles: 365; sterile spikelets: very few. Where the spikelets have been broken as, for example, in threshing, it is not possible to determine accurately the proportions of the types of spikelet originally present. The relationship between the numbers of main and bosom grains measures the excess of either singles or trebles. The figure used is the number of main grains present in a random sample of 1,000 grains. In a series of 72 samples from 36 crops an average of 509 main grains per 1,000 was found. Fifty-five of the samples gave main grain counts between 490 and 510, only one was below 480 (an excess of trebles), and eight were above 520. These samples were from several oat varieties and were complete in that they were threshed by hand and not winnowed. Of the 59 varieties described by Peachey (1951) only one, New Minor, is stated to give mainly trebles, whereas 24 of the varieties are said to give some spikelets of this type.

To investigate further the question of spikelet make-up, 10 panicles were taken at random from five fields drilled with unidentified varieties. The panicles were divided to give roughly equal numbers of spikelets in each section and then dissected to give the results shown in Table 1. This table shows that the majority of the trebles were at the tops of the panicles whereas singles and sterile spikelets tended to occur lower down. Sheals (1950) found that about 85 per cent of the sterile spikelets occurred in the lower thirds of the panicles.

TABLE 1

NUMBERS OF GRAINS PER SPIKELET ACCORDING TO POSITION IN THE PANICLE

Position in Panicle	Number of Spikelets			
	Sterile	Single	Double	Treble
Apical	0	2	257	22
Middle	2	20	300	10
Basal	11	47	271	2

WEIGHT AND KERNEL CONTENT OF HEALTHY GRAIN

The weights of husk, kernel, and whole grain, together with the kernel content for each class of grain from the 1953 Onward samples are given in Table 2.

TABLE 2

AVERAGE WEIGHT (MG) AND KERNEL CONTENT ACCORDING TO CLASS OF GRAIN

Class	Number of Grains in Sample	Husk	Kernel	Whole Grain	Percentage Kernel
Singles	294	8·9	23·8	32·7	72·9
Doubles					
Main	7,967	13·5	31·7	45·2	70·1
Bosom	8,651	6·6	21·1	27·7	76·0
Trebles					
Main	319	17·5	40·6	58·1	70·0
Second	336	10·4	31·8	42·2	75·4
Third	329	3·5	15·5	19·0	81·7
Means					
Doubles		10·1	26·4	36·5	72·3
Trebles		10·5	29·3	39·8	73·6
Singles + trebles		10·1	27·9	38·0	73·4

The results in Table 2 suggest that grains from singles were lighter than other main grains, and had a higher kernel content. In this connection it is of interest to note that in the samples examined by Berry (1920) the kernel content of singles was lower than that of the other main grains. It is also evident that main grains from trebles were heavier than other main grains, and were of lower kernel content; and further that the kernel content of bosom grains was higher than that of main grains, third grains having the highest kernel content of all. Comparison of the singles data with the trebles mean shows that an excess of trebles (less than 500 main grains per 1,000) is likely to be associated with a higher average grain weight, whereas the kernel content is likely to be relatively unaffected, other things being equal. The relationship between the numbers of doubles and the numbers of singles and trebles may vary for any given number of main grains per 1,000. If the mean values for doubles are compared with those for equal numbers of singles and trebles it is clear that such variation probably has little effect on grain weight or kernel content.

Table 2 also indicates the general relationships between the average weights of the different classes of grain in the panicle. It is of interest to carry this analysis further and determine the relationship between main and bosom grains in the same two-grained spikelet. The relevant data are shown in Table 3, and they suggest that there is a close correlation between the kernel weights of main and bosom grains from individual doubles from five fields of unidentified variety. The class interval in Table 3 is 3 mg, the middle term being given along each

axis. Thus there were 59 doubles in which the main kernel weighed 28, 29 or 30 mg and the bosom kernel 19, 20 or 21 mg. In general, the results in Table 3 suggest that the weight of the main grain kernel exceeds that of the associated bosom grain kernel by about 10 mg. This figure seems applicable to all the varieties examined, with the exception of Forward where the average difference was about 15 mg.

TABLE 3

COMPARISON OF KERNEL WEIGHTS WITHIN THE SPIKELET

Weight of bosom kernel (mg)	2	5	8	11	14	17	20	23	26	29	32	35	38	41	44
35															1
32															2
29											1	4	14	8	
26										2	4	29	22		
23									1	10	37	45	4	1	
20								2	9	59	43	8	1		
17							1	6	38	37	6				
14						1	4	26	21	9					
11							10	5	1	2					
8					1	2	2								
5															
2															

Weight of main kernel (mg)

A comparison of whole grain weights within spikelets has been made and is shown in Table 4, which is made up of mean weights, the individual samples being of either 10 or 50 doubles each. From this table it seems clear that the main grain is usually about 18 mg heavier than the bosom grain, while the bracketed figures, which refer only to Forward, suggest a difference of about 24 mg in this variety. The bulk of the table is made up of data from the varieties Black Supreme, Blenda, Eagle, Lightning, S.147, S.225, Star, Sun II, and Victory. There appeared to be slight, but consistent, differences between some of the samples.

TABLE 4

COMPARISON OF WHOLE GRAIN WEIGHTS WITHIN THE SPIKELET

Weight of bosom grain (mg)	26	29	32	35	38	41	44	47	50	53	56
38											1
35									1	1	1
32								7	11	1	(1)
29						2	8	24	3	(7)	
26					1	8	24	8	2(4)	(1)	
23				4	4	12	2	(1)	(1)		
20			2	4	3	2					
17			2	1	1						
14											

Weight of main grain (mg)

A table similar to Table 4 can be constructed to show the relationship between weights of husk and kernel. In this case the points are found to lie along a slightly curved line. The ratio between husk and kernel weights is best studied by calculating the kernel content. Hutchinson *et al.* (1952, 1953) found a good relationship between kernel content and kernel weight in Victory, and significant differences in kernel content between varieties and environments, as well as that the kernel content of bosom grains was higher than that of main grains. The latter was also noticed by Berry in 1920, and has already been emphasized in the present paper (Table 2). An example of the relationship between grain weight and kernel content is given in Table 5. The figures are means of 100 healthy grains each from different parts of the panicles of a sample of Blenda.

It appears that the superiority of bosom grains in kernel percentage is maintained throughout the panicle.

TABLE 5

THE RELATIONSHIP BETWEEN KERNEL CONTENT AND WEIGHT OF GRAIN

Type of Grain	Sub-samples					
Main						
Weight (mg)	50·4	47·8	45·6	43·4	42·0	39·0
Percentage K	75·8	74·7	74·7	73·9	73·3	73·2
Bosom						
Weight (mg)	33·1	32·3	29·2	27·6	25·3	22·3
Percentage K	80·1	79·9	78·9	78·9	78·6	77·6

In all the samples examined it was found that the grain weights increased from the base to the apex of the panicle. This is illustrated in Table 6 by data from three oat varieties, each average being based on the dissection of a sample of 10 panicles.

TABLE 6

GRAIN WEIGHT (MG) ACCORDING TO POSITION IN THE PANICLE

Whorl No.	Blenda		Forward		Lightning	
	Main	Bosom	Main	Bosom	Main	Bosom
1–3	50·1	33·1	57·2	32·8	51·4	33·3
4	48·7	32·0	54·6	29·8	49·2	30·6
5	46·8	29·8	53·0	28·7	47·8	29·1
6	43·4	27·6	50·9	26·2	46·7	28·0
7	—	—	49·5	24·2	43·5	25·8

It seems here that main and bosom grains behave quite consistently in the three varieties tested, the apical ones always being appreciably heavier than those lower down. This point was investigated further in that in some of the samples the spikelets of whorls 5 and 6 were divided into approximately equal numbers of those nearest the main stem (proximal), and those further away (distal); the average grain weights were then found, and are given in Table 7.

TABLE 7

GRAIN WEIGHT ACCORDING TO DISTANCE FROM THE MAIN STEM

Variety	Whorl	Main Grains		Bosom Grains	
		Proximal	Distal	Proximal	Distal
Forward	5	50·9	54·3	26·1	29·3
	6	48·3	52·9	23·4	28·3
Lightning ..	5	45·5	48·3	26·7	29·7
	6	43·5	45·2	25·0	28·2
Blenda	5	46·1	49·0	28·9	32·1
	6	42·2	46·7	26·5	30·3
Means		46·1	49·4	26·1	29·7
Differences ..		3·3 ± 0·451 (5Df)		3·6 ± 0·292 (5Df)	

With regard to Table 7 it should be noted that, as shown by Bonnett (1937), the spikelets in the upper parts of the panicle and the distal parts of the lateral

branches are those differentiated and formed first. Within the spikelet, main florets are differentiated and formed before bosom florets. Fryer and Collin (1924) imply that the upper spikelets also lead in the shedding of pollen and in fertilization. The results in Table 7 suggest that this early advantage is maintained through to the end point of mature grain since, in both the main and bosom components, grains from whorl 5 were consistently heavier than those from whorl 6, and the average weight of both types of grain from the distal end of the spikelets is significantly ($P = 0{\cdot}01$) greater than that of the proximal grains.

In an attempt to determine the relationship, if any, between grain weight and kernel content on the one hand and panicle size on the other, three analyses were carried out. In the first, two samples, each of 10 panicles, were dissected and the kernels weighed in relation to panicle size. The results showed that the smaller panicles (judged from the number of fertile spikelets present) gave main and bosom kernels which were consistently heavier than those in the larger panicles. A second trial, in which one sample of 20 panicles of each of the varieties Blenda, Forward and Lightning was dissected, indicated that main grains were consistently lighter in the smaller panicles. In the third test, main grain weights were determined for five series each of 10 panicles which were graded in size from the smallest to the largest before dissection. Two of the series referred to Black Supreme, two to Sun II, and the fifth to Star. The results were bulked in respect of variety, and tabulated in two groups depending on whether the individual panicles were smaller or larger than the mean value for each sample. The overall mean weight of main grains from the larger panicles was 43·3 mg and from the smaller panicles 41·9 mg. The difference of 1·4 mg has a standard error of 0·806 (9 Df) and it seems safe to suggest that the data as a whole provide no real evidence that grain weight is dependent on panicle size.

BLIND OAT GRAINS

In the course of this work, grains have been noticed in which the kernel has failed to develop. In such grains the husk appears to be of normal size but may be paler in colour than in a normal grain, especially in varieties such as Black Supreme. The kernel shows no sign of external injury but is less than a quarter the length of a normal kernel. In the notes which follow, no reference is made, or intended, to the sterile spikelets in which neither husk nor kernel is fully developed (Sheals, 1950) which are to be found commonly near the base of the oat panicle, nor is reference made to the condition in which parts of the panicle are dwarfed or malformed due to frost or insect damage (Roebuck, 1920). In such cases both husk and kernel are reduced.

Blindness, as here understood, is therefore rather different from the blindness discussed by Cunliffe and Fryer (1924) who included all instances where the kernel was not developed through causes other than Frit fly. With this reservation in mind Cunliffe and Fryer's results can be examined. They dissected two series of 12 oat varieties and found 9·8 and 7·4 per cent of the grains to be blind respectively. Subsequently, Cunliffe (1930) correlated sterility with variety, but not with the incidence of either Frit fly or Cereal thrips or time of flowering. Cunliffe and Hodges (1946) found blindness to be more common in later panicles and among bosom grains, and to be unaffected by manurial levels.

In the present work the incidence of blind grains has been studied in a series of commercial crops in 1954 and 1955. In each case approximately half of the field was sprayed with DDT early in May to investigate Frit fly control; in 16 cases (from nine crops in 1955) samples of 25 panicles were examined in detail and the distribution of blind grains noted; and from each half-field of each of

36 fields in the DDT spraying trials, 50 random grab samples of about 10 panicles each were taken at harvest time. A sub-sample of 150 panicles was picked at random from the 500 taken in each half-field, and these were threshed by hand and random samples of 500 main and 500 bosom grains taken for dissection. About 25 main and 25 bosom grains occurred in each panicle. At a level of 5 per cent blindness this would give a sub-sample containing about 375 blind grains, and the main and bosom grain samples would together contain about 50 blind grains.

Blindness estimates made in this way varied from 0·8 to 9·2 per cent for different fields, the mean being 3·5 per cent. There was no apparent relationship between blindness and Frit fly attack. Of the 10 oat varieties included in the investigations only three occurred sufficiently often for good averages to be calculated. These are given in Table 8. There was significantly less blindness in Blenda than in Star ($P = 0·02$).

TABLE 8

DEGREE OF BLINDNESS IN THREE OAT VARIETIES

Variety	Number of Replicates	Mean Percentage of Blindness (All Grains) Angular Transformation	Detransformed
Blenda	9	8·6 ± 0·638	2·3
Star ..	8	12·9 ± 1·165	5·0
Sun II ..	7	10·4 ± 1·032	3·3

Blindness was next investigated in relation to its position in the spikelet. Table 9 shows the mean percentage of blindness among main and bosom grains and in the sprayed and unsprayed parts of the experimental oat fields.

TABLE 9

PERCENTAGE DEGREE OF BLINDNESS IN 36 OAT CROPS FROM DDT TRIALS

	Class of Grain		Treatment	
	Main	Bosom	Sprayed	Not Sprayed
Detransformed percentage ..	3·25	3·70	3·30	3·63
In angular transformation ..	10·38	11·08	10·46	10·99
Standard error for transformed means	0·387 (105 Df)		0·387 (105 Df)	

Once in about 12 trials a difference between main and bosom grains as great as 0·70 would be obtained quite by chance. Although this difference does not reach the 20 per cent level commonly accepted as a fair test of the significance of biological data, it does tend to support the statement by Cunliffe and Hodges (1946) that blindness is more common among bosom than among main grains. Examination of a further set of samples did, in fact, show that blindness among the bosom grains was significantly greater than among the associated mains (Table 10). Apparently DDT sprays at tillering have no effect on blindness in the grain three months later.

Data from the 16 samples of 25 panicles each taken from nine crops in 1955 have been analysed to investigate blindness in relation to the position of the affected spikelets in the panicle. The results are set out in Table 10 and it should be noted that they are based on at least (whorl No. 1) 400 grains per whorl. Analysis of these percentages, after angular transformation, indicates that the variation in percentage blindness with position in the panicle is probably a chance effect.

TABLE 10

PERCENTAGE OF TRUE BLINDNESS IN EACH WHORL

Type of Grain	Whorl No. 1	2	3	4	5	6	7	Transformed Mean	S.E.
Main	2·50	3·13	2·85	3·25	2·42	2·47	3·44	9·7	0·333
Bosom	4·50	4·12	4·86	3·77	3·84	3·20	3·14	11·3	0·333
Transformed means	10·7	10·9	11·3	10·8	10·1	9·7	10·4		0·882

On the assumption that blind grains are distributed at random between panicles within a crop, the expected variation in blind grains per panicle has been calculated. This has been expressed as the number of panicles in each sample with 0, 1, 2, or more than 2 blind grains, and the observed distribution is compared with that expected on this basis in Table 11. Expected numbers from individual samples were too low for useful comparisons to be made, but it appears that there is close agreement between observed and expected results for main and bosom grains separately although when they are bulked the discrepancy is probably too great to be attributed to chance effects.

TABLE 11

DISTRIBUTION OF BLIND GRAINS BETWEEN PANICLES

Type of Grain	Numbers of Panicles with Blind Grains: Absent	1	2	More than 2	Probability of Observed Equalling Expected Value
Main					
Observed	219	116	39	26	
Expected	210	117	48	25	0·5 — 0·7
Bosom					
Observed	222	110	34	34	
Expected	207	108	43	42	0·2 — 0·3
All grains bulked					
Observed	134	131	62	73	
Expected	123	114	69	94	0·02 — 0·05

The same 25-panicle counts have been rearranged so that, for each sample, the incidence of blindness can be compared as between the 12 largest and the 12 smallest. In the 192 large panicles there were 433/12,512 blind grains, compared with 213/6,701 in the 192 smaller panicles. The individual data, analysed in angular transformation, give overall means of blindness of 9·81 and 9·88 for the large and small panicles respectively (2·93 and 2·97 per cent respectively detransformed). These means do not differ significantly although there were significantly ($P = 0·01$) more blind grains on the larger panicles.

CONCLUSIONS

The weight of a healthy oat grain is shown to depend (within the limits of biological variation) on three factors.

1. Position in the spikelet. The difference in weight between main and bosom grains is constant within a variety and independent of the total spikelet weight (Tables 3 and 4).

2. Position of the spikelet within the panicle. Spikelets at the apex and at the ends of the lateral branches are heavier than those nearer the base (Tables 6 and 7).

3. A factor common to all the grains in the panicle but which is not related directly to panicle size. This factor may be the expression of the balance between the number of spikelet primordia in the newly-formed inflorescence and the amount of nutriment available for their development.

The kernel content is greater in bosom grains than in main grains but within each class is positively correlated with grain weight (Table 5). Kernel content is also dependent on variety and is probably influenced by environment. It may be noted that according to Hunter (1951) the kernel content is the most important factor governing the feeding or commercial value of an oat sample.

Observations on blind grains support those of previous workers. The degree of blindness was greater among bosom grains than among main grains and was related to the variety. Blind grains were found to occur practically at random within the panicle, and the percentage of grains in this condition was not related to panicle size.

The degree of intensity of Frit fly attack within and between panicles has been studied and the data will be given in the second part of this paper. The photograph was taken by Mr. W. E. Perry.

REFERENCES

ARMSTRONG, S. F. (1937). *British Grasses and their Employment in Agriculture*. 3rd Edition, Cambridge University Press. 14.

BERRY, R. A. (1920). Composition and Properties of Oat Grain and Straw. *J. agric. Sci.*, **10**, 360–414.

BONNETT, O. T. (1937). The Development of the Oat Panicle. *J. agric. Res.*, **54**, 927–31.

CUNLIFFE, N. (1930). Studies on *Oscinella frit* Linn. Comparative Records of Oat Grain Infestation in Sweden during the Year 1927, together with a Note on Sterility or "Blindness" of Grain. *Ann. appl. Biol.*, **17**, 549–53.

CUNLIFFE, N. and FRYER, J. C. F. (1924). *Oscinella frit* Linn. An Investigation to Determine How Far Varietal Differences May Influence Infestation of the Oat Plant. *Ann. appl. Biol.*, **11**, 465–81.

CUNLIFFE, N. and HODGES, D. J. (1946). Studies on *Oscinella frit* Linn. Notes on the Resistance of Cereals to Infestation. *Ann. appl. Biol.*, **33**, 339–60.

FRYER, J. C. F. and COLLIN, J. E. (1924). Certain Aspects of the Damage to Oats by the Frit Fly. *Ann. appl. Biol.*, **11**, 448–64.

HUNTER, H. (1951). *Crop Varieties*. Spon, London, 85–9.

HUTCHINSON, J. B., KENT, N. L. and MARTIN, H. F. (1952). The Kernel Content of Oats. Variation in Percentage Kernel Content and 1,000 Kernel Weight Within the Variety. *J. nat. Inst. agric. Bot.*, **6**, 149–60.

HUTCHINSON, J. B., KENT, N. L. and MARTIN, H. F. (1953). The Kernel Content of Oats. Comparisons of Kernel Content and Thousand Kernel Weight for Winter and Spring Varieties. *J. nat. Inst. agric. Bot.*, **6**, 443–53.

HUTCHINSON, J. B., KENT, N. L. and MARTIN, H. F. (1954). Oat Kernels with Decayed Embryos: a Factor in the Germination Capacity of Oats. *J. nat. Inst. agric. Bot.*, 7, 24–32.

PEACHEY, R. A. (1951). *Cereal Varieties in Great Britain*. Crosby Lockwood, London.

ROEBUCK, A. (1920). Frit Fly (*Oscinis frit*) in Relation to Blindness in Oats. *Ann. appl. Biol.*, **7**, 178–82.

SHEALS, J. G. (1950). Observations on Blindness in Oats. *Ann. appl. Biol.*, **37**, 397–406.

THOMAS, J. D. (1954). Survey of Damage to Oats by Frit Fly in England and Wales, 1947–51. *Plant Pathology*, **3**, 55–8.

ZINN, J. and SURFACE, F. M. (1917). Studies on Oat Breeding—V: The F_1 and F_2 Generations on a Cross Between a Naked and a Hulled Oat. *J. agric. Res.*, **10**, 293–312.

AN IMPROVED CYST COUNTING TRAY

by R. P. C. JOHNSON

Temporary Worker in the Nematology Department, Rothamsted Experimental Station

The cyst counting tray described by Fenwick (*J. Helminth.*, 1940, **18**, 155–72) was made by soldering copper wire on to a shallow tin plate tray to form a continuous counting channel. In an alternative method the ridges are made by running a blunt seeker along the back of a piece of zinc foil and mounting this corrugated surface in cement in a suitable shallow tin. With both of these methods it is difficult to make the whole surface of the tray level and the microscope has to be continually refocussed. The trays must also be painted white, and the paint tends to chip with use.

An improved tray can be made out of a suitable piece of $\frac{1}{4}$-inch white Perspex by milling out the central area to form a tray about $\frac{1}{8}$ inch deep, $2\frac{1}{2}$ inches wide, and $3\frac{1}{2}$ inches long. Shallow counting channels are milled in the bottom of the tray with an $\frac{1}{8}$-inch end-mill which gives a convenient channel width. When the ends of alternate ridges thus formed are milled away to the same depth as the grooves between them to connect adjacent channels at alternate ends, a continuous counting channel is formed. Using the milling tool in a power drill with the Perspex level and the milling depth fixed, a perfectly level surface is ensured. A convenient way of moving the tray past the milling tool is to fix it to the slide rest of a lathe previously placed on the drill stage. The surface of the tray can be trimmed with a scalpel and rubbed down with steel wool to smooth the tops and sides of the ridges.

NEW OR UNCOMMON PLANT DISEASES AND PESTS

***Mimeuria ulmiphila* Del Gu. on Raspberry Roots.** This obscure aphid, which lives in unique cysts composed of the mycelium of a fungus on the roots of elm, was recorded in November 1956 living in exactly similar conditions on roots of raspberry in a garden at Leominster, Herefordshire. There was an elm hedge within four feet of the raspberries at the nearest point, and probably some intermingling of roots occurred; but at least one complete raspberry seedling bearing a typical cyst with an adult aphid in it was forwarded to H. L. G. Stroyan at the Plant Pathology Laboratory, so it is clear that the normal symbiotic association of aphid and fungus can develop on a host other than elm. The aphid seems to be widespread but overlooked, being now recorded also from Devon, Herts and Northants. Its full life cycle is still not known.

J. D. R. VERNON

***Phytophthora infestans* on Petunia and Datura.** On August 17, 1956 a blotch was noticed on a single leaf of some petunia plants (*Petunia hybrida*) growing in a private garden in Harpenden. Two days later similar blotches had appeared on seven or eight leaves on the same or adjacent plants. The blotches were up to one inch or more across, mostly extending inwards from, or associated with, the leaf margins, and causing crimping of the leaves (Plate III, 2). The upper surfaces of the blotches were matt brown in colour, with a distinct pale green margin; the under surfaces bore numerous sporangiophores of *Phytophthora infestans* (Mont.) de Bary. On August 20, the same disease was found about half a mile away in a bed of petunias on the Rothamsted Experimental Station. In both instances blight was present on potatoes only a few yards from the petunias. Weather conditions were very favourable for the development of blight during the next two or three weeks, but though it became destructive to potatoes in the neighbourhood, it did not spread to any extent on the petunias and caused no appreciable damage to them. On August 21, similar lesions caused by *P. infestans* were found on leaves of *Datura stramonium* growing outside the glasshouses at Rothamsted. The only previous record in Britain of the fungus on petunia was at Bristol a century ago (Berkeley, *Gdnrs' Chron.*, 1856, **16**, 644) and there is no previous record of its natural occurrence on Datura, although Müller (*Nature, Lond.*, 1950, **166**, 392–5) reported successful artificial inoculation in a glasshouse. Dr. W. Black kindly tested isolates of the fungus from leaves of the affected petunias and Datura and found that both belonged to race 4.

J. M. HIRST AND W. C. MOORE

***Glomerella cingulata* causing a Die-back of Privet.** In September 1956, Mr. J. Lloyd of Shinfield, Berks, drew my attention to a privet hedge showing an unusual dying back of the young shoots. On examination, this dying back was found to be associated with a fungal lesion forming a girdling canker at the base of the shoot affected. The die-back was confined to new or one-year-old shoots, and was sometimes associated with a trimming snag. The cankers were found to contain perithecia resembling *Glomerella cingulata* (Stonem.) Spauld & Schrenk, which was confirmed by the Plant Pathology Laboratory, Harpenden. The symptoms and the fungus resembled an anthracnose of privet as described in America by Mix (*Phytopathology*, 1925, **15**, 261–72). The fungus was isolated both from diseased tissue and from asci, and produced sporodochia of *Gloeosporium* profusely on artificial media. The fungus was then inoculated into several varieties of apple fruits, both by slice and stab inoculations, and a typical bitter rot of apple was produced, with abundant production of sporodochia, but perithecia were not found. Wounded control fruits were unaffected. Detached privet branches standing in water, and small shoots kept on moist filter paper in petri dishes, were also inoculated, but the inoculations were not successful; the lesions did not extend and perithecia were not found. However, immature perithecia were produced on corn meal agar. It is interesting to note that the privet hedge was adjacent to an old apple orchard, and it had been the practice to leave all the old clippings which fell " on the other side " to accumulate for years, thus providing ideal conditions for a build-up of the fungus. Golden privet in the vicinity was unaffected. This would appear to be the second record of *Glomerella cingulata* causing a die-back of privet in England, since Brooks (*Plant Diseases*, 1953, Oxford University Press, 230) also recorded that it had been seen.

E. T. ROBERTS

(69238) Wt. 24 K.9 6/57 Hw.